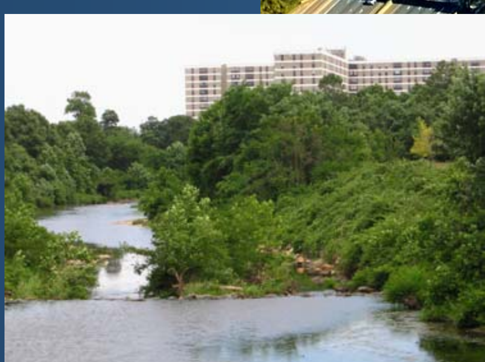
Bacteria Total Maximum Daily Load Studies for Hunting Creek, Cameron Run, and Holmes Run



Technical Advisory Committee Meeting
June 25, 2010

Meeting Agenda

- **Introductions and Administrative Updates**
  Bryant Thomas, VA Department of Environmental Quality

- **Non-Tidal TMDL for Cameron Run and Holmes Run**
  Ross Mandel, Interstate Commission on the Potomac River Basin

- **Tidal ELCIRC Model Calibration**
  Harry Wang, Virginia Institute of Marine Science

- **Discussion**
  Bryant Thomas, VA Department of Environmental Quality

Why are we here?

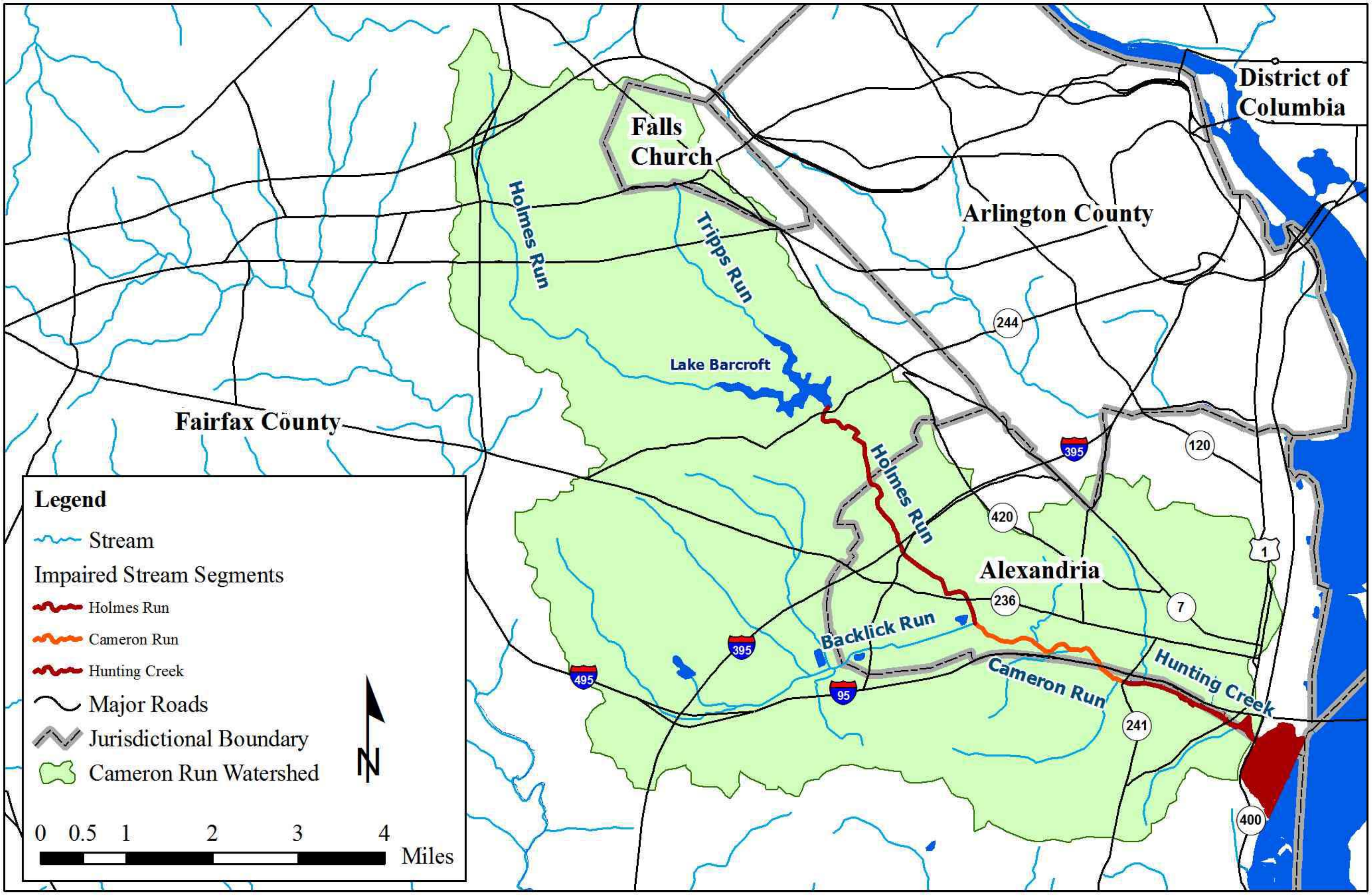
- **Hunting Creek, Cameron Run, and portions of Holmes Run do not meet the water quality standards recreational use.**

Stream Name	Area	Upstream Limit	Downstream Limit	DEQ Monitoring Stations	Exceedance Rate*
Hunting Creek (Tidal)	**0.53 square miles**	**Route 241 (Telegraph Road) Bridge Crossing**	**Confluence with the Potomac River**	**Station 1aHUT000.01** *(Located at the George Washington Memorial Parkway)*	**11 of 17 samples** *(40.7% exceedance)*
				Station 1aHUT001.72 *(Located at Telegraph Road)*	**3 of 11 samples** *(27.3% exceedance)*
Cameron Run (Non-Tidal)	**2.08 miles**	**Confluence with Backlick Run**	**Route 241 (Telegraph Road) Bridge Crossing**	**Station 1aCAM002.92** *(Located at Eisenhower Avenue)*	**5 of 18 samples** *(27.8% exceedance)*
Holmes Run (Non-Tidal)	**3.58 miles**	**Mouth of Lake Barcroft**	**Confluence with Backlick Run**	**Station 1aHOR001.04** *(Located at Pickett Street)*	**3 of 12 samples** *(25% exceedance)*

- **Attainment of the recreational use is assessed using *E. coli* monitoring data. The *E. coli* criterion is 126 cfu/100 ml as a geometric mean. If insufficient data to compute a GM, then assessed against 235 cfu/100 ml allowing a 10% exceedance rate.**

*** Exceedance rates taken from the 2008 Integrated Assessment, which looked at data from 01/01/2001 to 12/31/2006.**

Location of Impaired Segments



Project Updates

Project Updates (Technical)

- Comment Period on Source Assessment Memo – October and November 2009
- Meeting with Relevant Jurisdictions for the Tidal TMDL (Alexandria and Fairfax) – February 2010 and June 2010
- Changes to the Tidal Model:
  - Developed ELCIRC Model Cells for Hooffs Run
  - Updated CSO Flows
  - Revised Calibration

Project Updates (Administrative)

- Agreement with EPA to extend this project until October 1, 2010.
- Triennial Review of Water Quality Standards was approved. Bacteria TMDLs now developed to meet the geometric mean criterion.

TMDL for Non-Tidal Cameron Run and Holmes Run

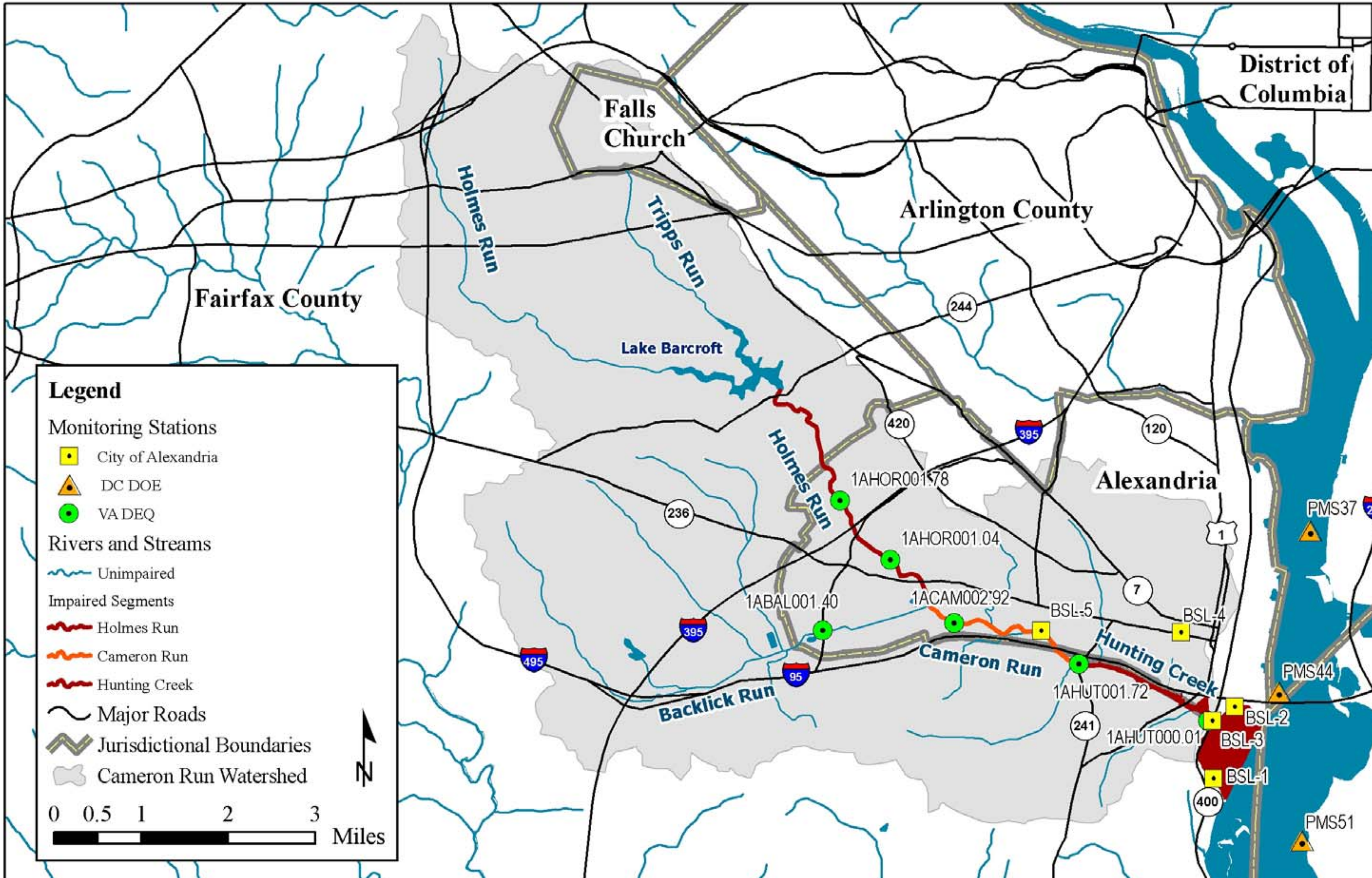
HSPF Watershed Model

- Calibration Period: 2001-2005
- TMDL Scenario Period: 2004 and 2005

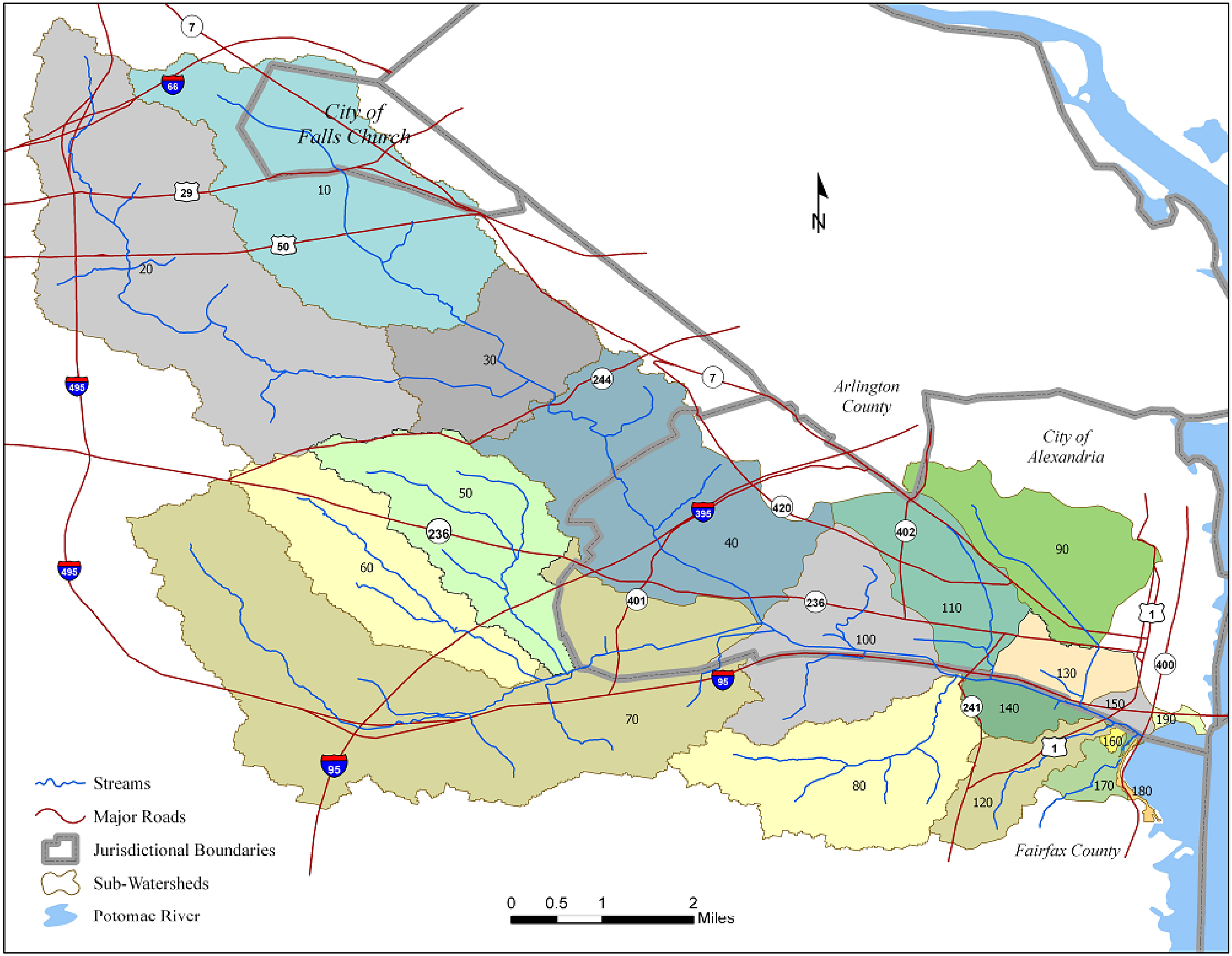
- Loading Rates (from Source Assessment): Septic Systems, SSOs, Wildlife, Pets.

- MS4: All land uses except Open Space (approximately 90% of watershed).

Monitoring Station Locations



HSPF Model Segmentation



HSPF Bacteria Calibration Targets

- **Compare Fecal Coliform (FC) geometric mean of observed Data with FC geometric mean of all simulated daily concentrations**

- **Convert FC to *E. coli* (EC) using DEQ Translator and compare exceedance rate of Single Sample Maximum *E. Coli* Criteria (235 #/ 100 ml) with exceedance rate of all simulated daily concentrations**

- **Adjust targets to take into account frequency of storm data**

HSPF Calibration Framework

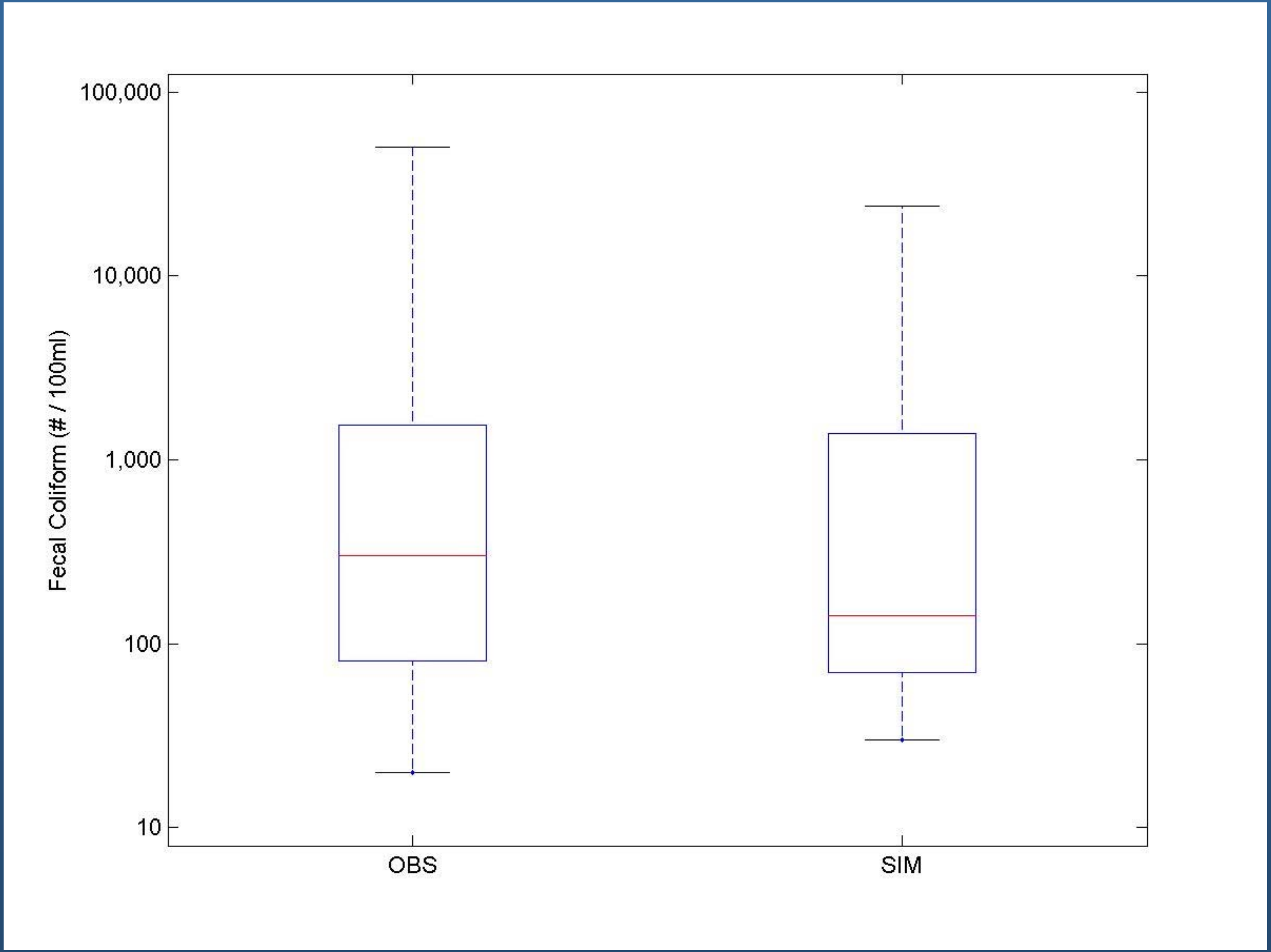
Stream	Stations	Segment Calibrated	Segments Applied
Holmes Run	HOR001.04	40	10-40
Backlick Run	BAL001.40	70	50-70
Cameron Run	BSL-5, CAM002.92	100	80, 100,120, 140, 160-180
Hooffs Run	BSL-4	90	90,110, 130,150

HSPF Calibration Results

Stream	Observed		Simulated	
	Geometric Mean	Exceedance Rate*	Geometric Mean	Exceedance Rate*
Holmes Run	209	0.38	258	0.39
Backlick Run	150	0.25	168	0.32
Cameron Run	269	0.40	293	0.40
Hooffs Run	1423	0.79	1427	0.79

** Instantaneous Maximum*

Fecal Coliform Bacteria - Cameron Run



Holmes Run TMDL Scenario Results (2004 and 2005)

Scenario:	Human Sources Reduction *(SSOs and Septic Systems)*	Wildlife Reduction *(Direct Deposition)*	Land Reduction	Exceedance Rate *(Monthly Geometric Mean)*
1	100%	0%	0%	54.2%
2	100%	0%	100%	0%
3	100%	100%	0%	16.7%
4	100%	50%	75%	4.2%
5	100%	50%	83%	0%

Non-Tidal Cameron Run TMDL Scenario Results (2004 and 2005)

Scenario:	Human Sources Reduction *(SSOs and Septic Systems)*	Wildlife Reduction *(Direct Deposition)*	Land Reduction	Exceedance Rate *(Monthly Geometric Mean)*
1	100%	0%	0%	66.7%
2	100%	0%	100%	0%
3	100%	100%	0%	12.5%
4	100%	50%	75%	4.2%
5	100%	50%	83%	0%

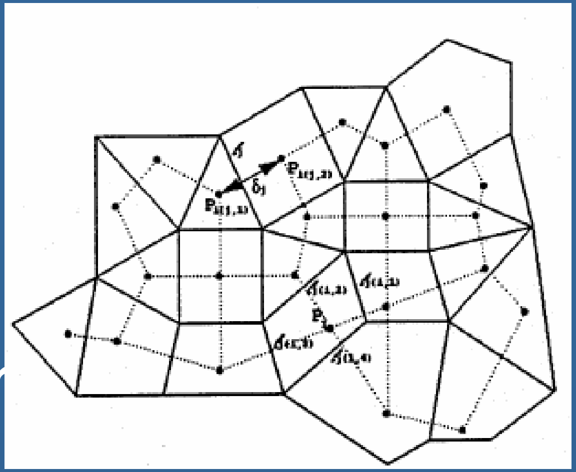
TMDL for Tidal Hunting Creek

Outline

- Hydrodynamic ELCIRC model
- Model domain and set up
- Model calibration and verification
- Sensitivity analysis

Hydrodynamic Model

http://www.ccalmr.ogi.edu/CORIE/modeling/elcirc/)

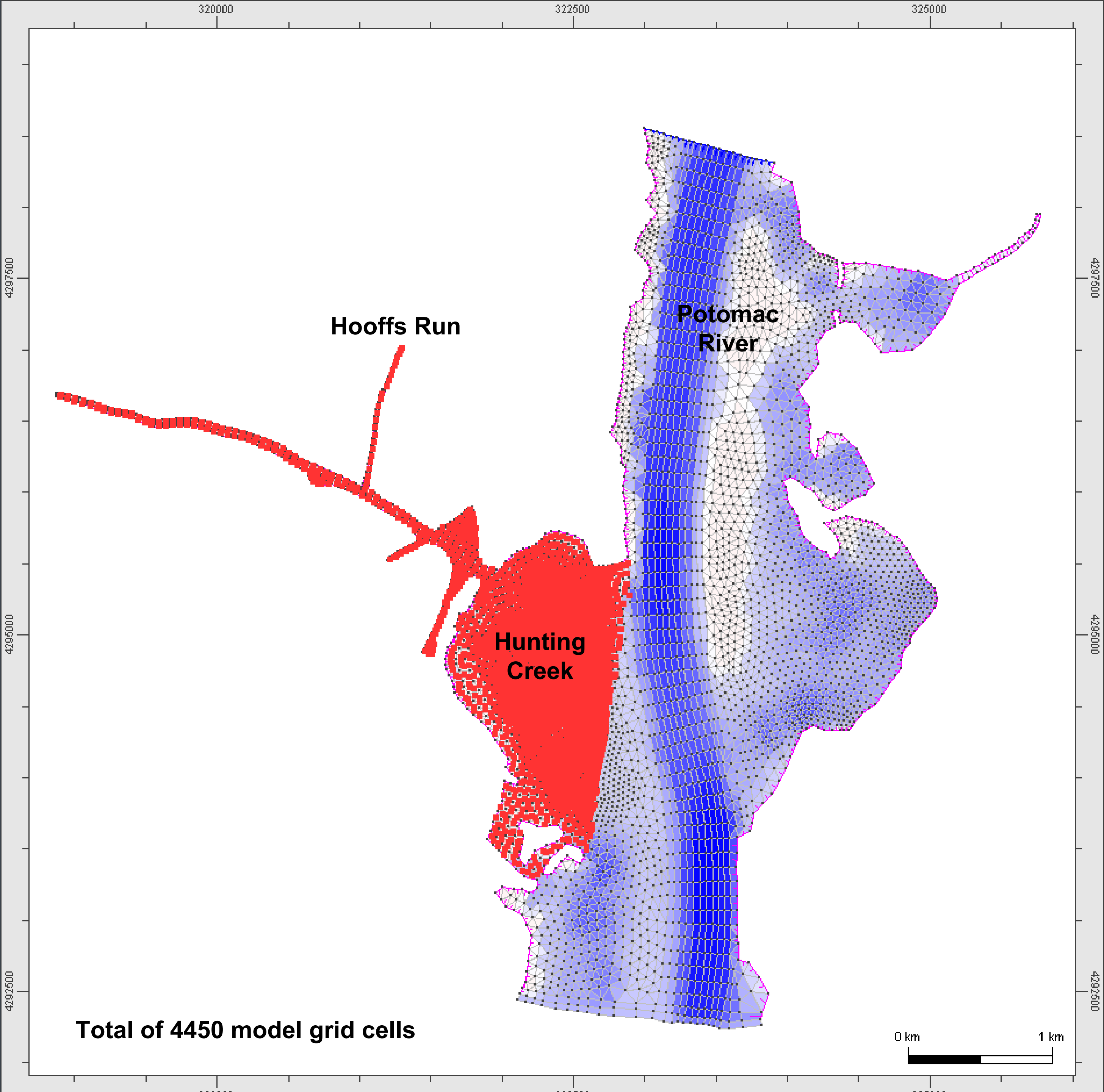


- Eulerian-Lagrangian Circulation (ELCIRC) Model
- Orthogonal unstructured grid
- Semi-implicit, finite-difference/finite-volume schemes
- Eulerian-Lagrangian advection scheme (Less restricted by CFL condition)
- Capable of simulating a wetting-and-drying process

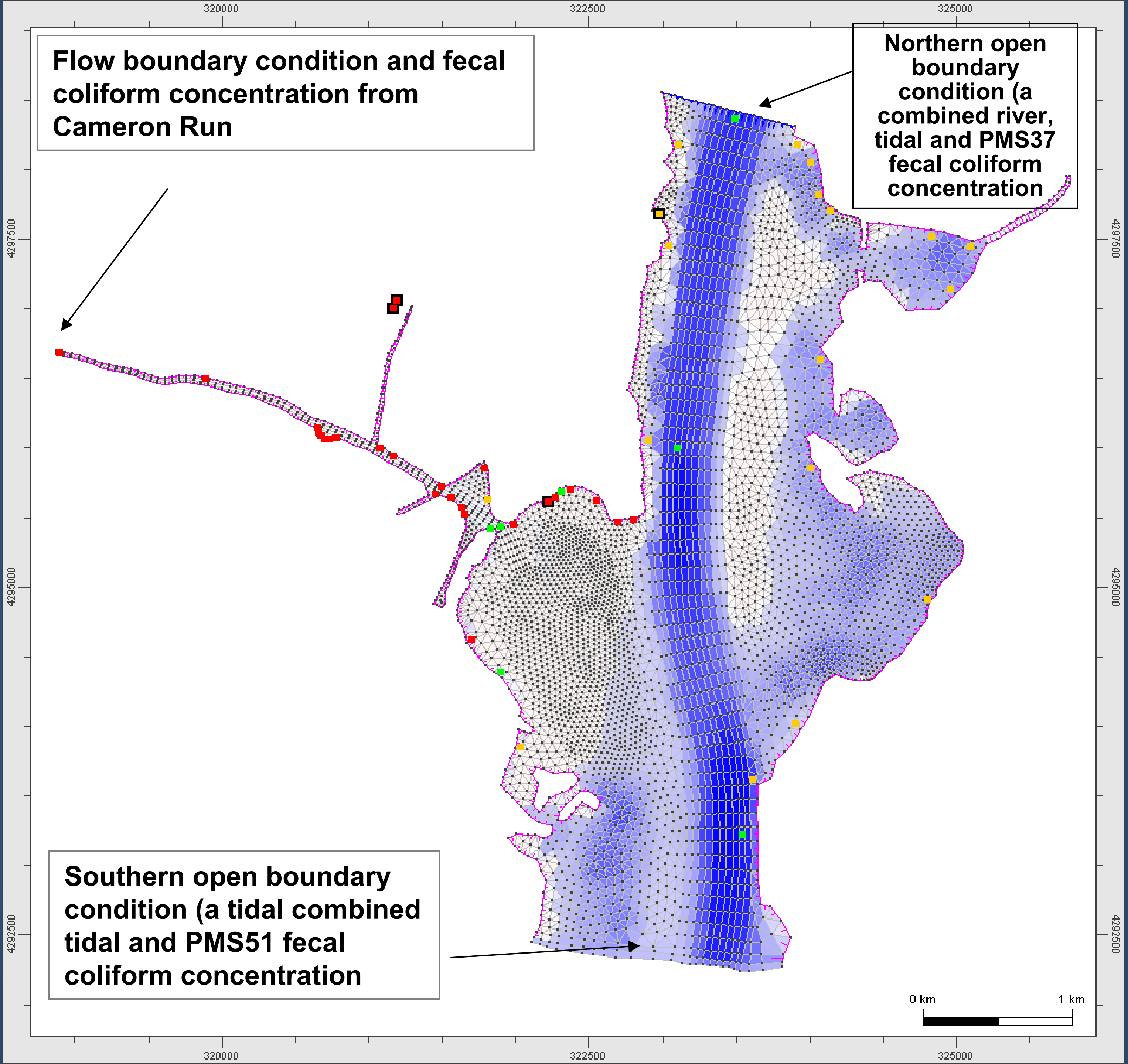
ELCIRC Model Domain

Red: Hunting Creek

Blue: Potomac River



Hydrodynamic Model Set Up



Model Calibration and Verification

(1) **Assumptions used in model application:**

a. Hydrostatic assumption.

b. Assume first decay for fecal coliform die-off rate.

c. Do not consider salinity and temperature dependency.

d. Do not consider a separated sediment model.

(2) **Technical basis for selected rates, constants and coefficients used in the modeling:**

a. The friction Chezy coefficient was determined by calibrating with observed tidal water level.

b. The first order decay constant was determined by calibrating with the observed Fecal Coliform data.

Analytical Solutions

We consider a system in which physical transport is primarily one dimensional; i.e., solute concentrations are horizontally and vertically well mixed such that concentrations vary only in the longitudinal or downstream direction. In addition, a steady, uniform flow field is imposed and the effects of dispersion are spatially constant. Finally, any biogeochemical processes may be described in terms of first-order reactions wherein the transformation rate is proportional to the solute concentration. Given these assumptions, conservation of mass yields the constant-parameter advection-dispersion equation with first-order decay (e.g., Runkel and Bencala, 1995):

$$\frac{\partial C}{\partial t} = -U\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} - \lambda C \qquad (1)$$

where C = concentration [ML^{-3}]; t = time [T]; U = flow velocity [LT^{-1}]; x = distance [L]; D = dispersion coefficient [$L^2 T^{-1}$]; and λ = first-order rate coefficient [T^{-1}].

Continuous Source of Infinite Duration

Two analytical solutions may be found in the literature for the case of a continuous source of infinite duration. Initial and boundary conditions for this case are given by:

$$\begin{aligned} C(x,0) &= 0 && \text{for } x \ge 0 \\ C(0,t) &= C_0 && \text{for } t \ge 0 \\ C(\infty,t) &= 0 && \text{for } t \ge 0 \end{aligned} \qquad (2)$$

where C_0 = concentration at the upstream boundary [ML^{-3}]. For the case of conservative solutes (λ = 0), the analytical solution is given by (Ogata and Banks, 1961):

$$C(x,t) = \frac{C_0}{2}\left[erfc\left(\frac{x-Ut}{2\sqrt{Dt}}\right) + exp\left(\frac{Ux}{D}\right)erfc\left(\frac{x+Ut}{2\sqrt{Dt}}\right)\right] \qquad (3)$$

The analytical solution for nonconservative solutes ($\lambda \neq 0$) is presented by Bear (1972, p. 630) and developed using Laplace transforms by O'Loughlin and Bowmer (1975):

$$C(x,t) = \frac{C_0}{2}\left[exp\left\{\frac{Ux}{2D}(1-\Gamma)\right\} erfc\left(\frac{x-Ut\Gamma}{2\sqrt{Dt}}\right) + exp\left\{\frac{Ux}{2D}(1+\Gamma)\right\} erfc\left(\frac{x+Ut\Gamma}{2\sqrt{Dt}}\right)\right] \qquad (4)$$

where

*Critical parameters which measure the relative importance of the first order decay rate λ are:

$$\Gamma = \sqrt{1+2H} \qquad (5)$$

$$H = \frac{2\lambda D}{U^2} \qquad (6)$$

Model Calibration and Verification

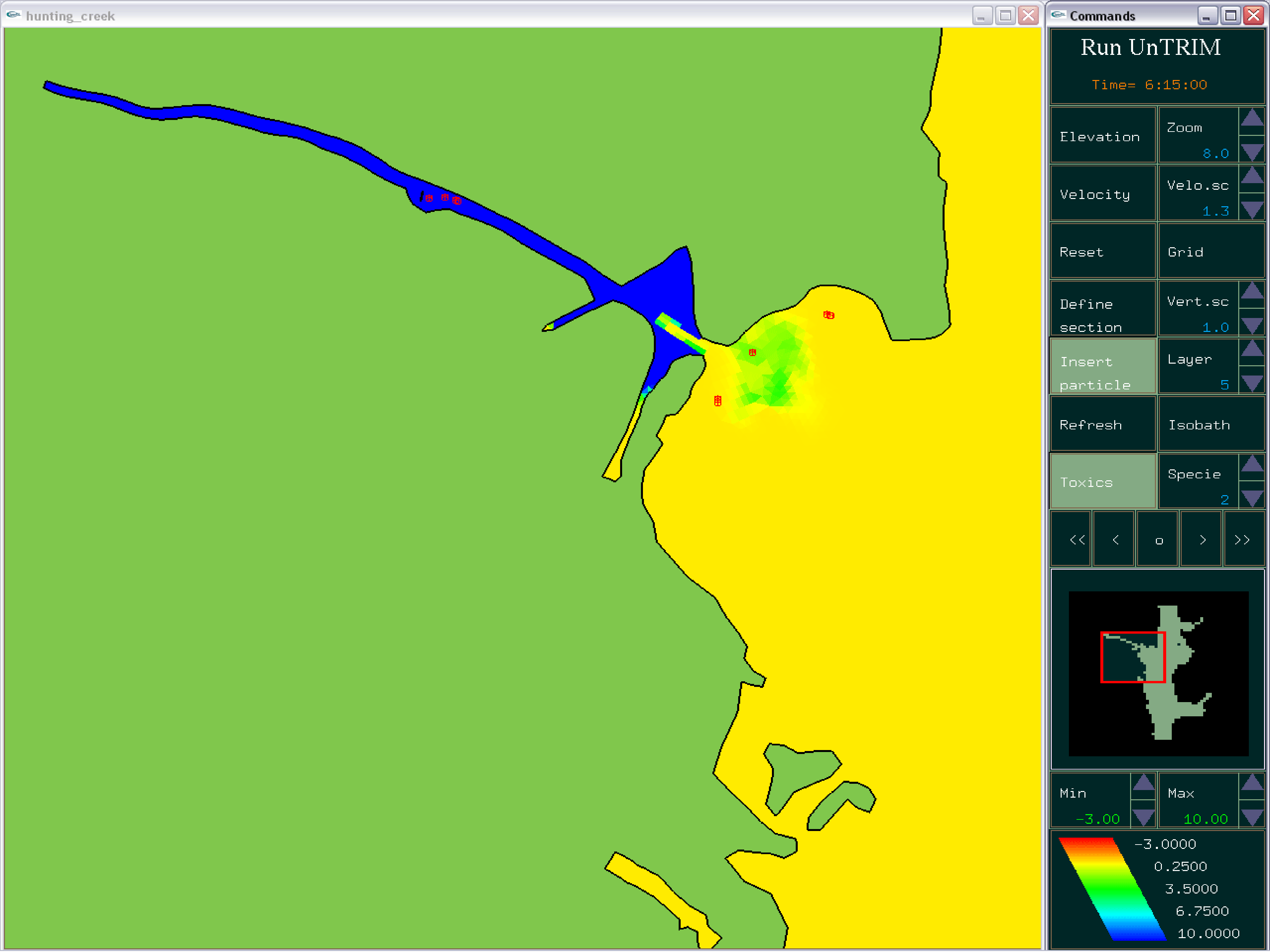
ELCIRC Calibration Period	2001-2003
ELCIRC Verification Period	2004-2005
ELCIRC TMDL Scenario Period	2004-2005

**2001 has a limited number of observations*
**2002 was a dry year, 2003 a wet year, and 2004 and 2005 were average flow years hydro-logically.*

ELCIRC Calibration Inputs Potomac

(outside of Hunting Creek Watershed)

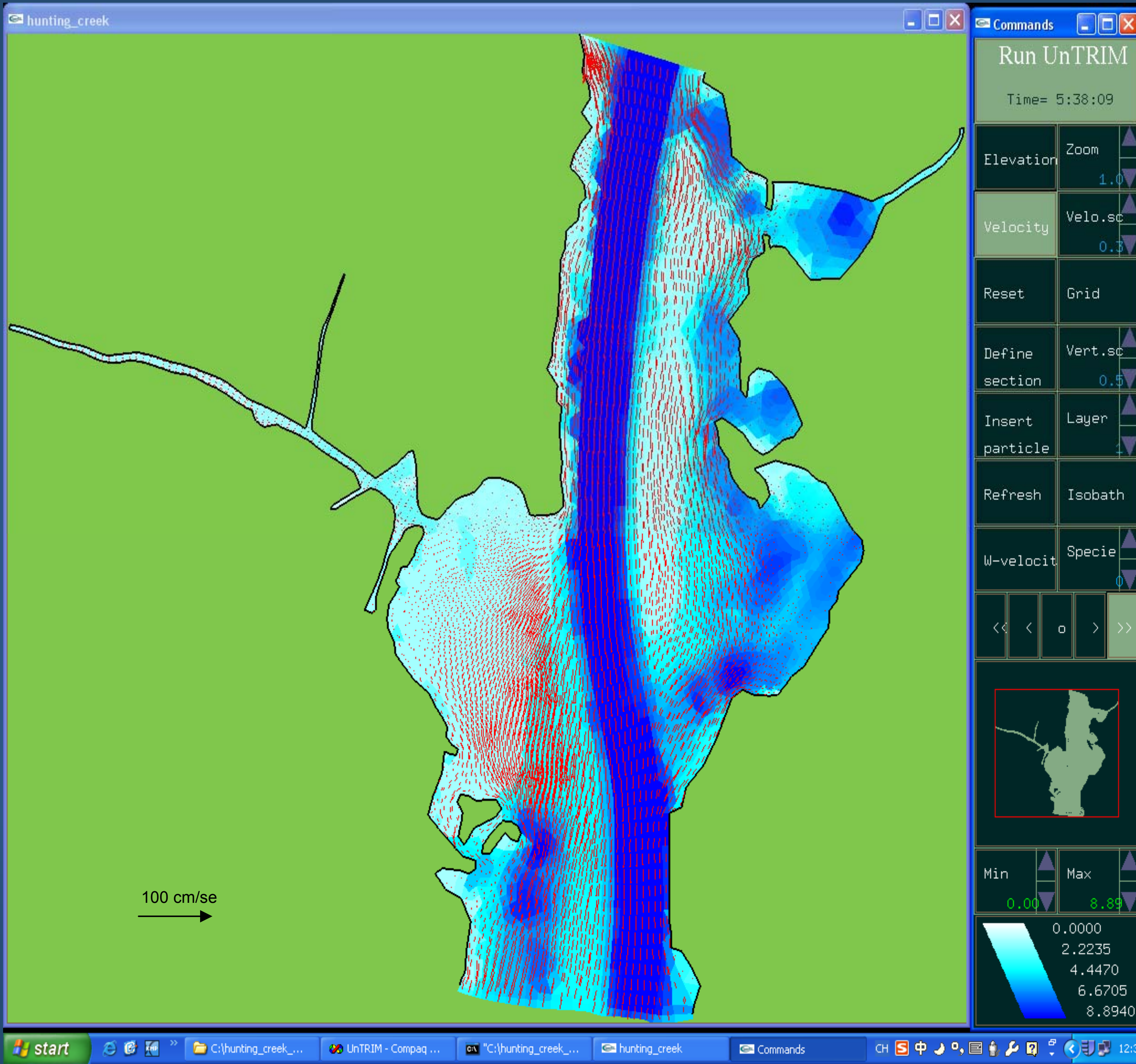
Source	Input Concentrations	Input Flows
Blue Plains	WASA Data	WASA Data
DC, MD Tidal Drainage	Oxon Run or other TMDLs	CBP P5 Model
VA Drainage	HSPF Segments	HSPF Segments
Boundary	DC DOE Monitoring Data	ELCIRC Model


hunting_creek
Commands
Run UnTRIM
Time= 6:15:00
Elevation
Zoom
8.0
Velocity
Velo.sc
1.3
Reset
Grid
Define section
Vert.sc
1.0
Insert particle
Layer
5
Refresh
Isobath
Toxics
Specie
2
<< < o > >>
Min
-3.00
Max
10.00
-3.0000
0.2500
3.5000
6.7500
10.0000

Hydrodynamic Model: Spatial Distribution of Velocity Fields in the Potomac River and Hunting Creek

Blue: bathymetry (in meters)

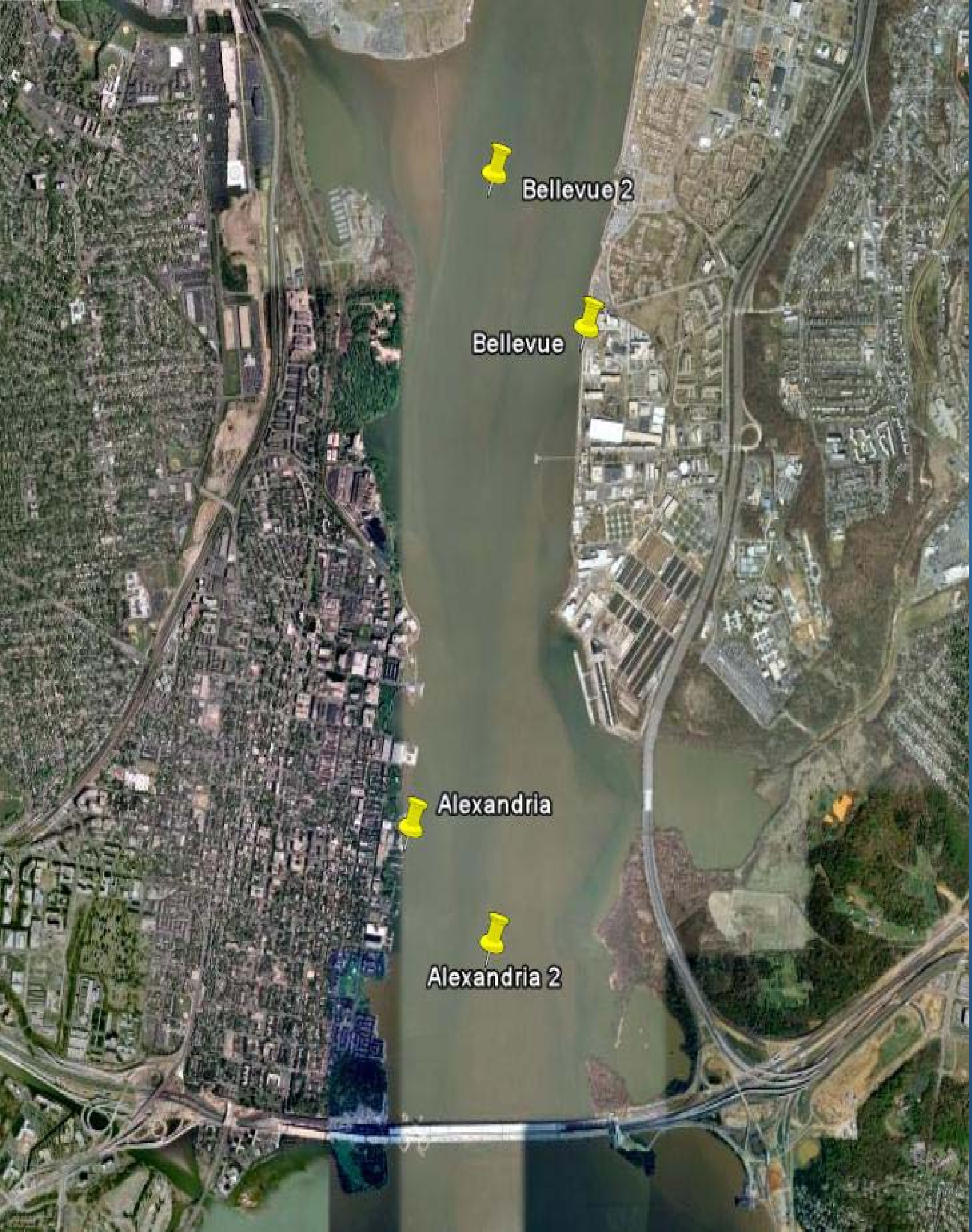
Red: magnitude and direction of velocity vector



Hydrodynamic Model: Spatial Distribution of Velocity Fields in Hunting Creek and Hooff's Run

Blue: bathymetry (in meters)

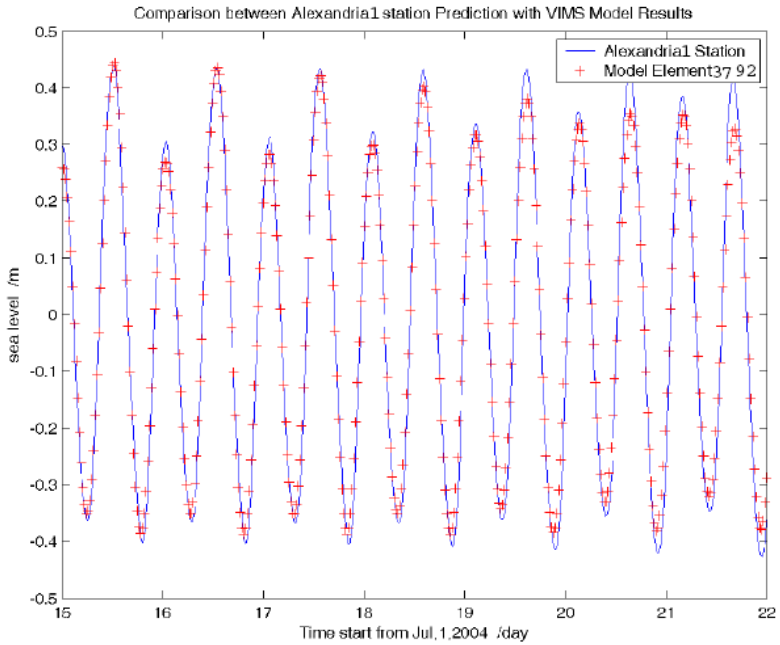
Red: magnitude and direction of velocity vector

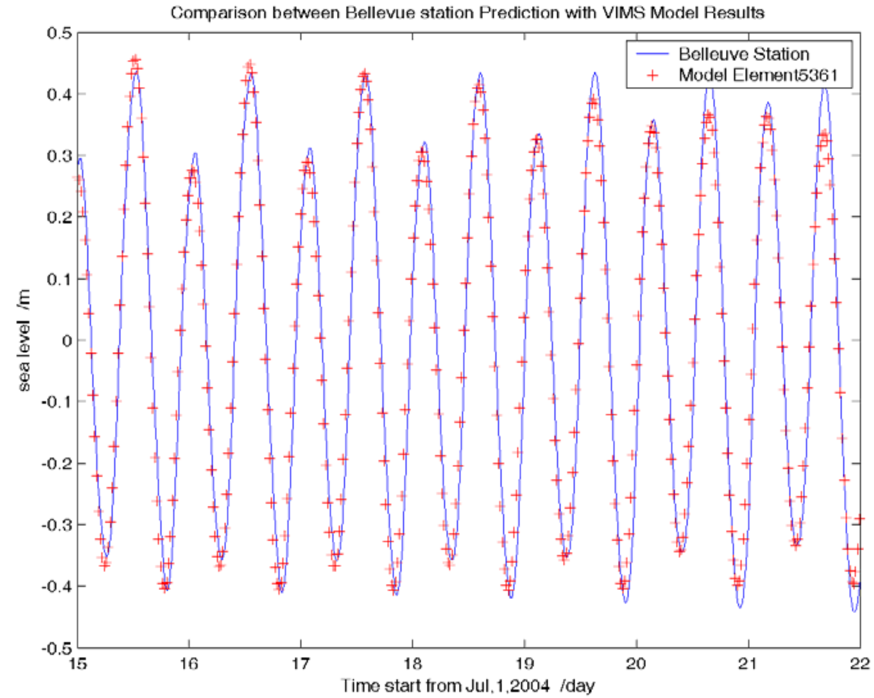


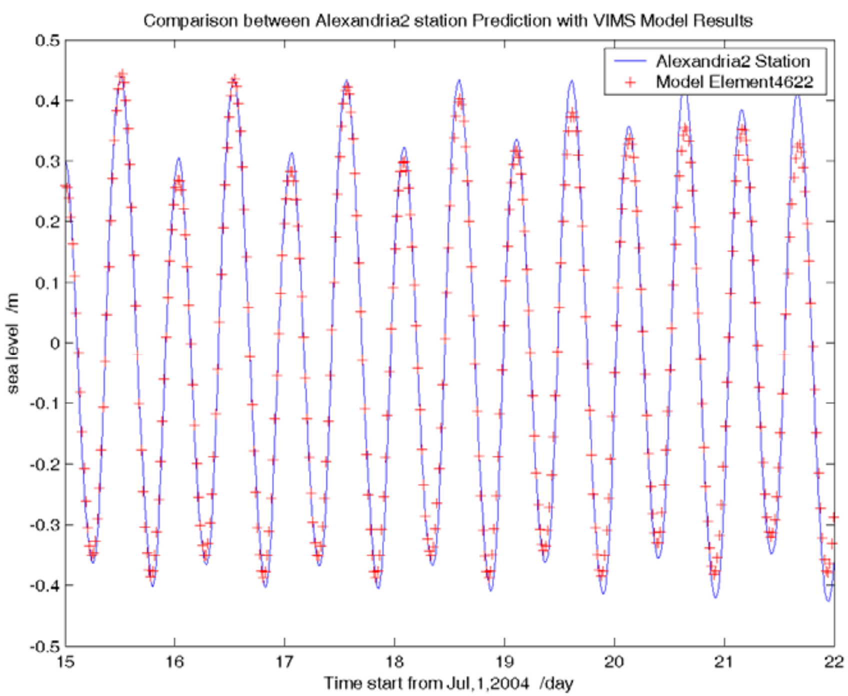
Hydrodynamic Calibration Time Series at Stations:

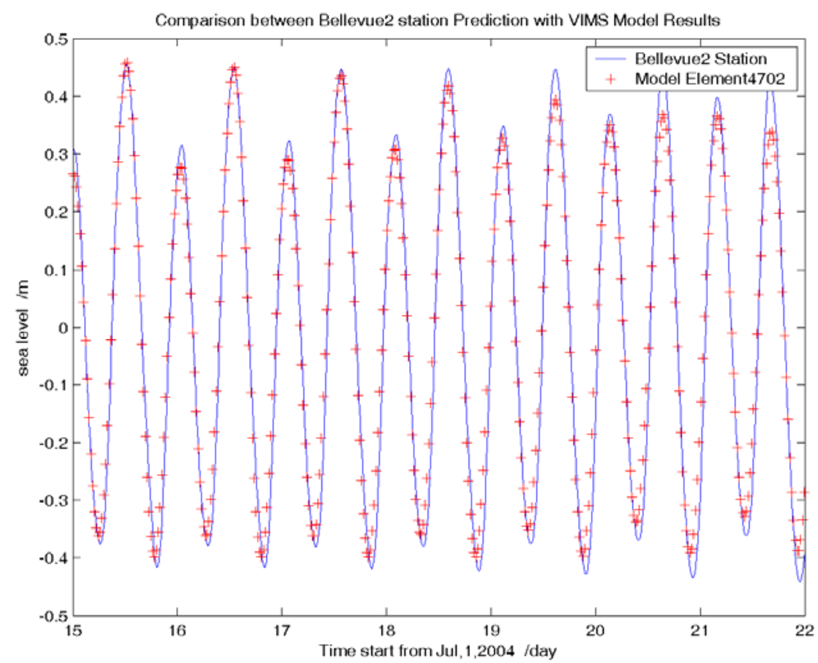
1. Bellevue
2. Belleuve2
3. Alexandria
4. Alexandria 2

stations	latitude	longitude
Bellevue	38.8267	-77.0267
Bellevue2	38.8333	-77.0333
Alexandria	38.805	-77.0383
Alexandra2	38.8	-77.0333

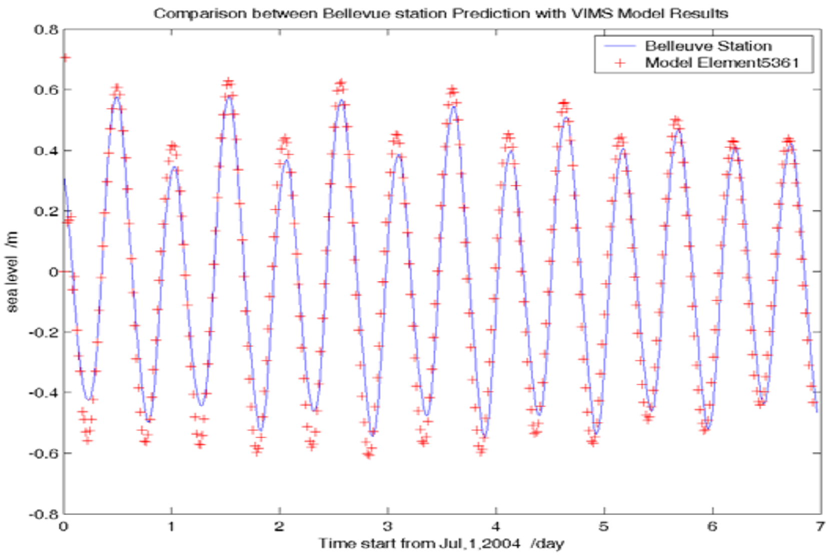

Comparison between Alexandria1 station Prediction with VIMS Model Results
Alexandria1 Station
Model Element37 92
sea level /m
Time start from Jul,1,2004 /day

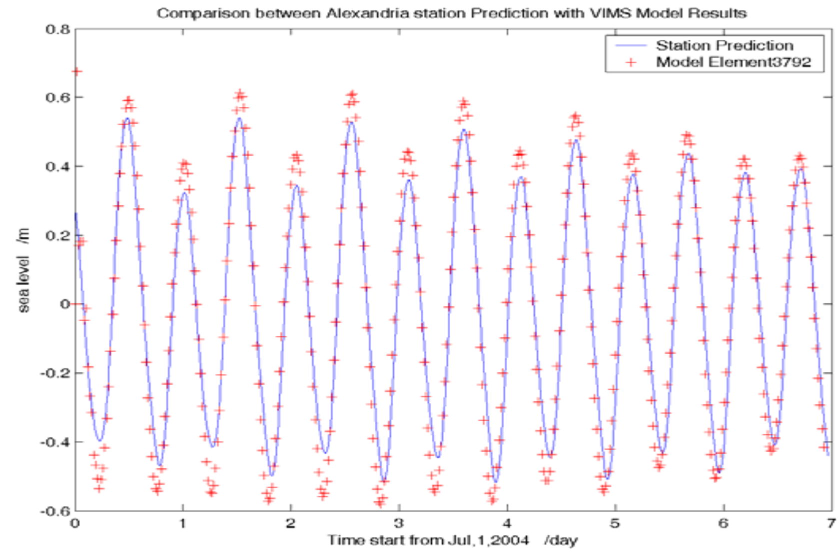

Comparison between Bellevue station Prediction with VIMS Model Results
Belleuve Station
Model Element5361
sea level /m
Time start from Jul,1,2004 /day


Comparison between Alexandria2 station Prediction with VIMS Model Results
Alexandria2 Station
Model Element4622
sea level /m
Time start from Jul,1,2004 /day

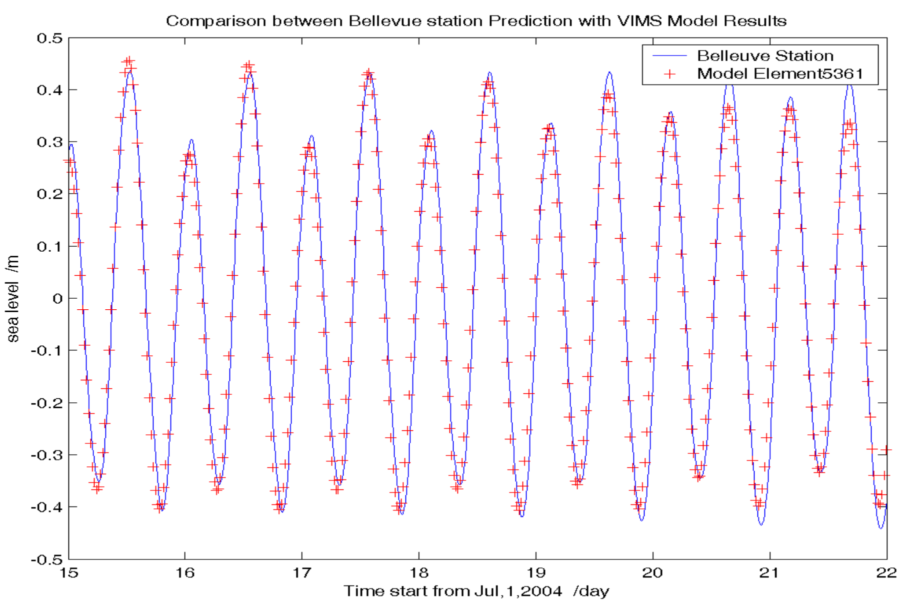

Comparison between Bellevue2 station Prediction with VIMS Model Results
Bellevue2 Station
Model Element4702
sea level /m
Time start from Jul,1,2004 /day

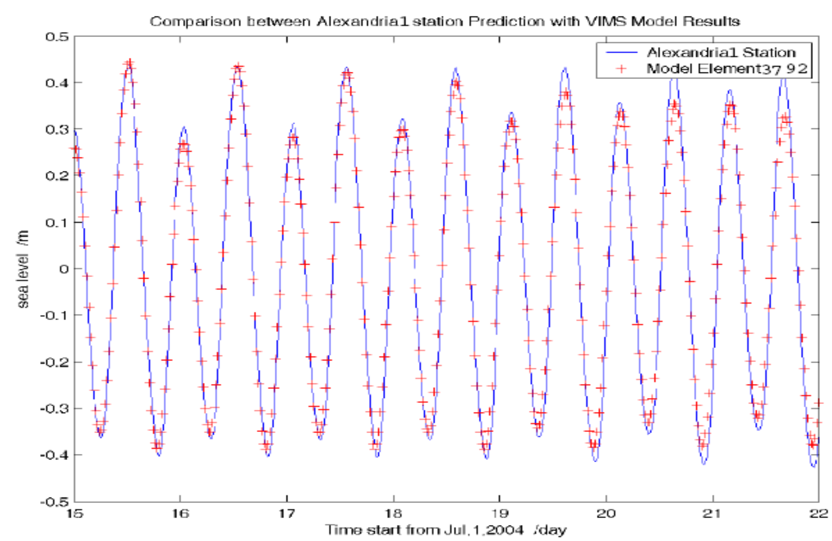
Before Calibration Chezy Coefficient =60

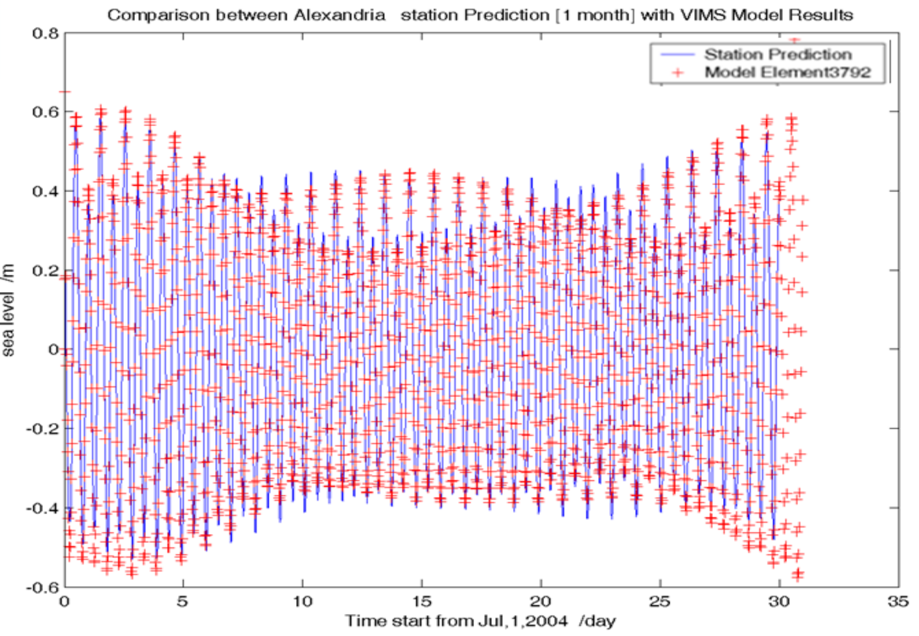


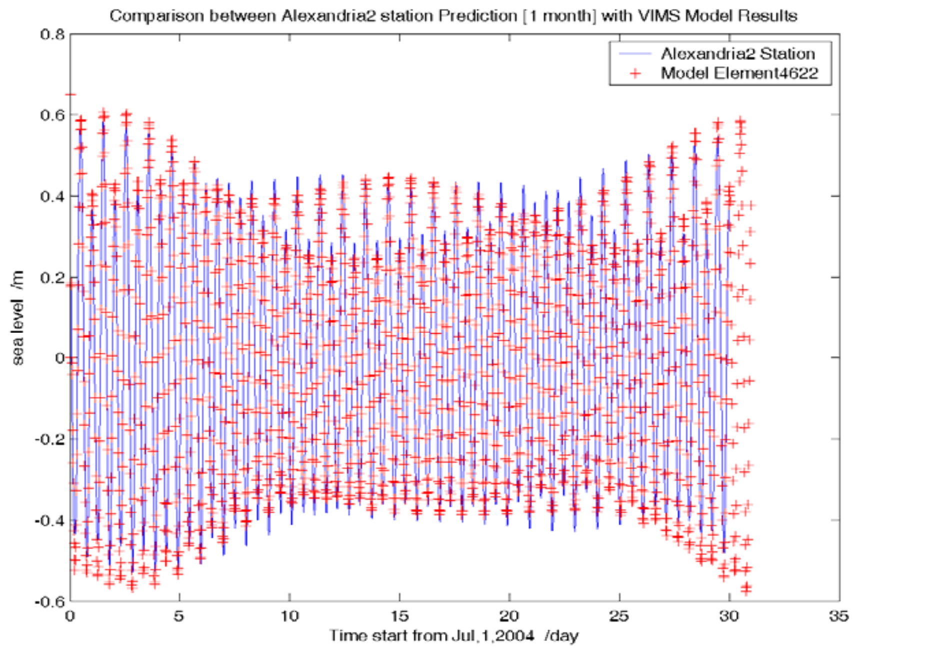


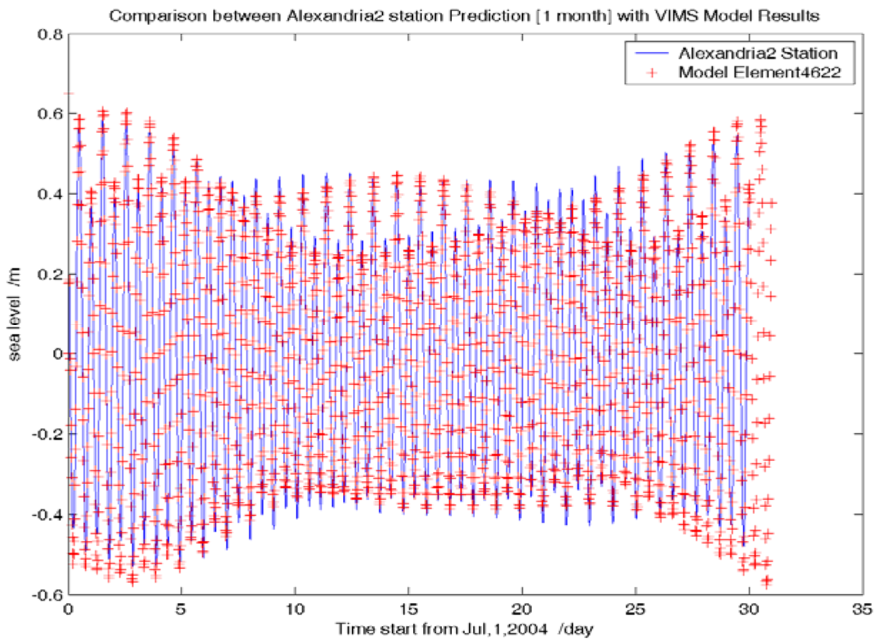
After calibration Chezy Coefficient =70

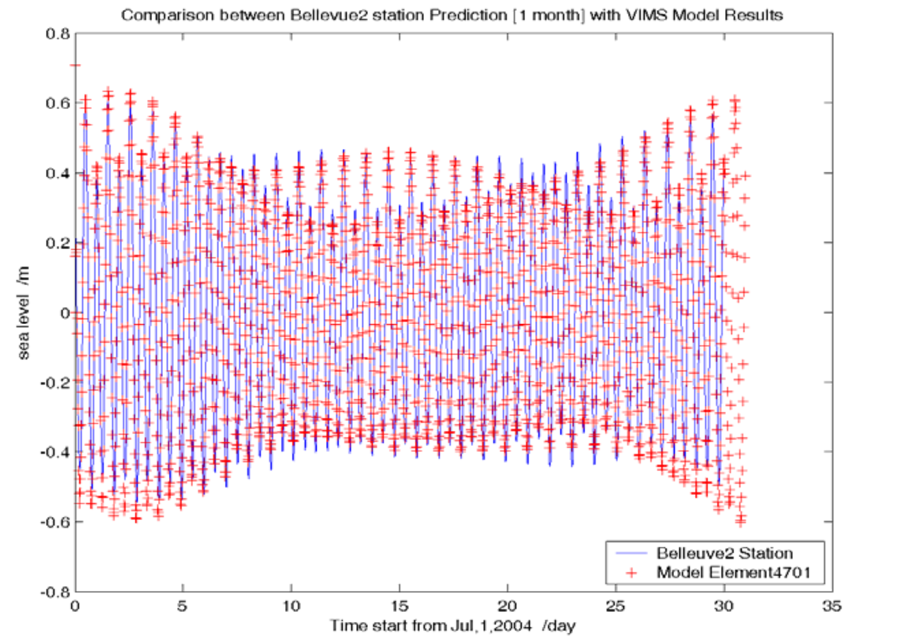






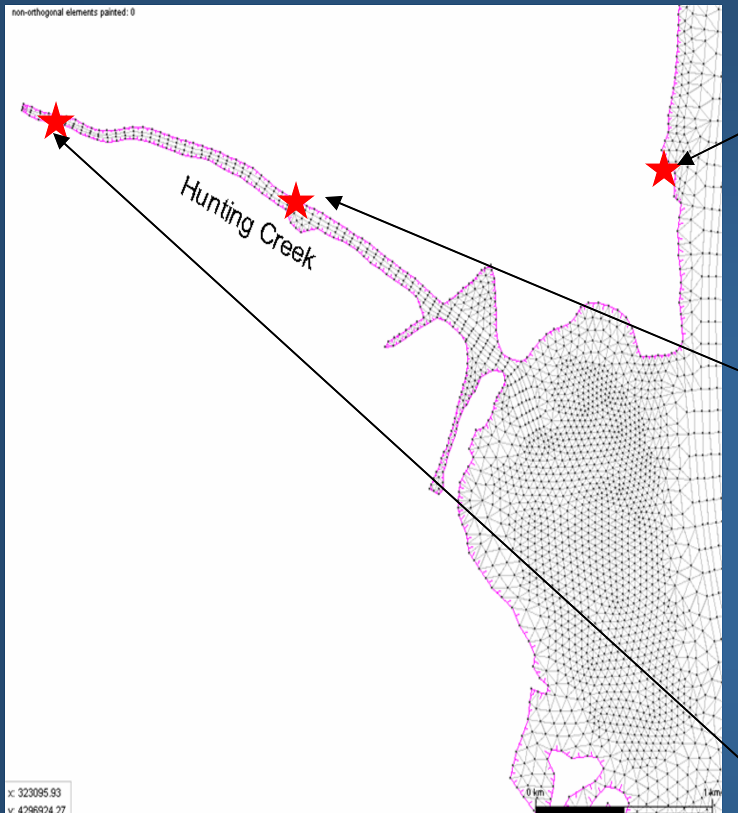


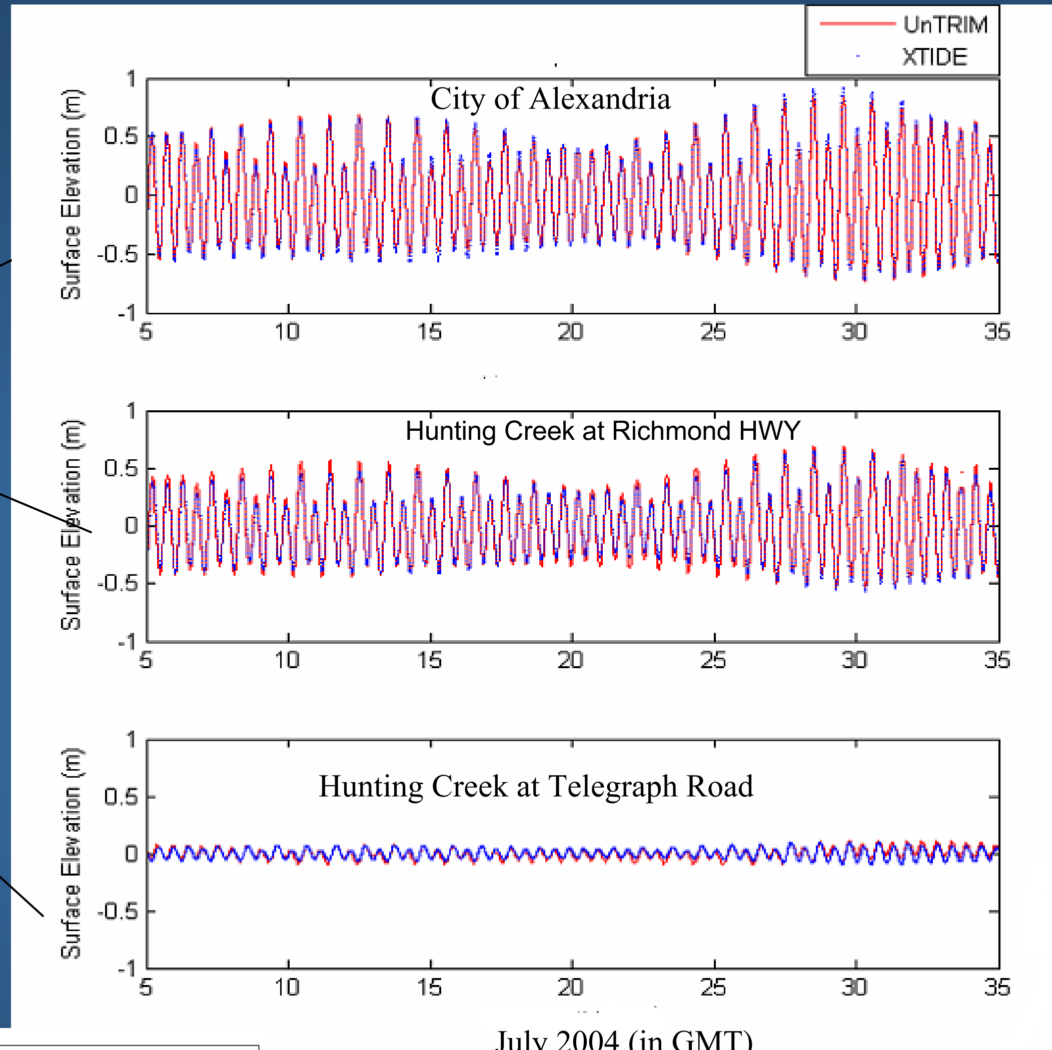


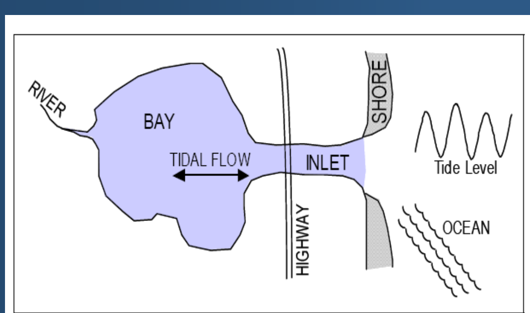


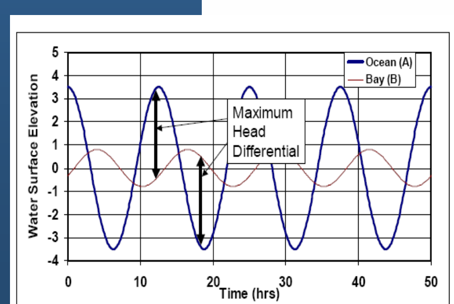
XTIDE is a harmonic tide predictor for X windows see http://www.flaterco.com/xtide/

Spatial Distribution of Tidal Amplitude in Hunting Creek









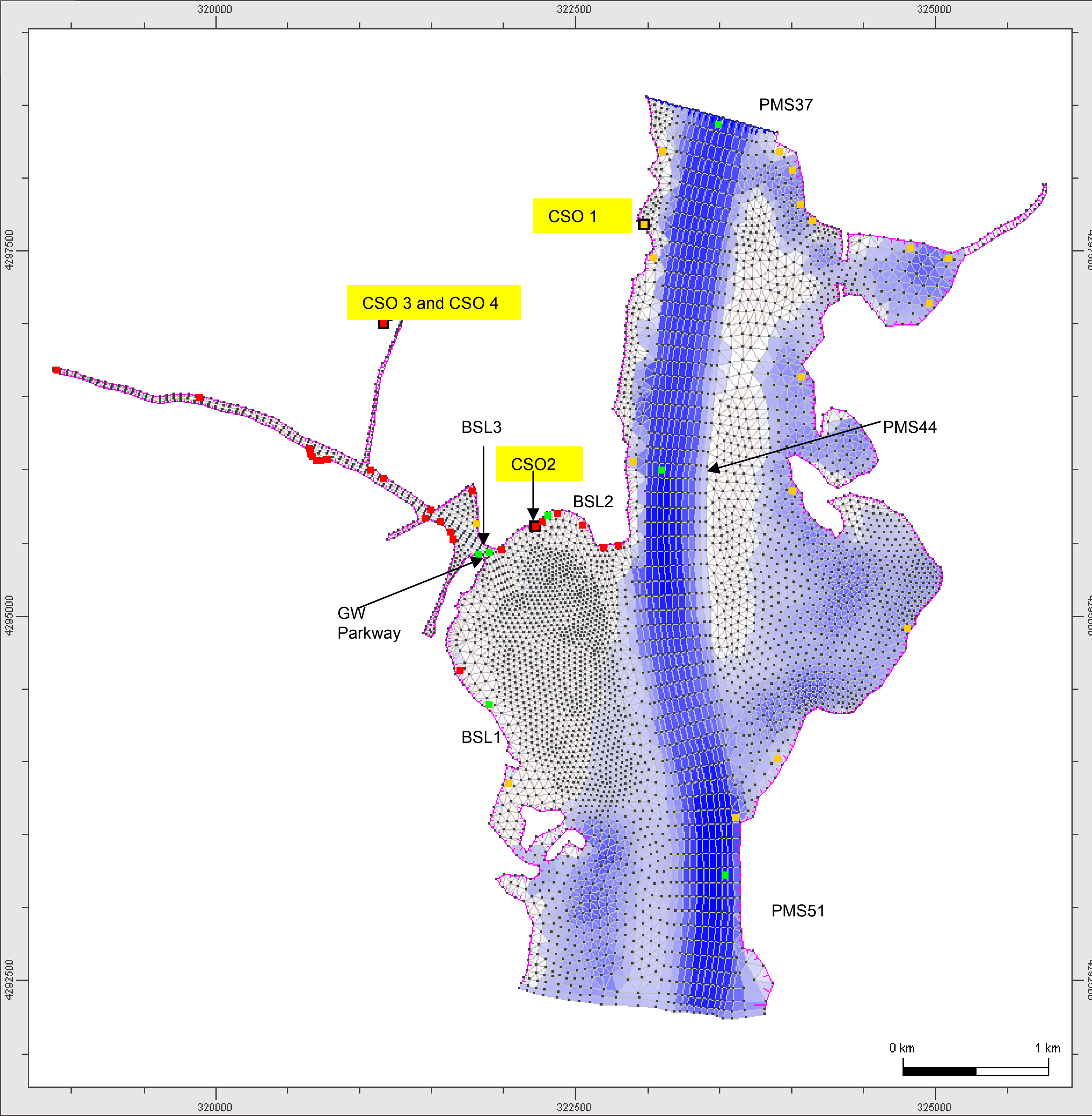
Source: "Tidal Hydrology, Hydraulics and Scour at Bridges"

US Department of transportation, Federal Highway Administration

ELCIRC Calibration Inputs Allocation Sources

(within the Hunting Creek Watershed)

Source	Input Concentrations	Input Flows
Non-tidal Cameron Run	HSPF Model	HSPF Model
Tidal Drainage (stormwater)	HSPF Model	HSPF Model
WWTP	Monthly Permit Reporting	Monthly Permit Reporting
CSOs	Event Mean Concentrations for each outfall	LTCP Model



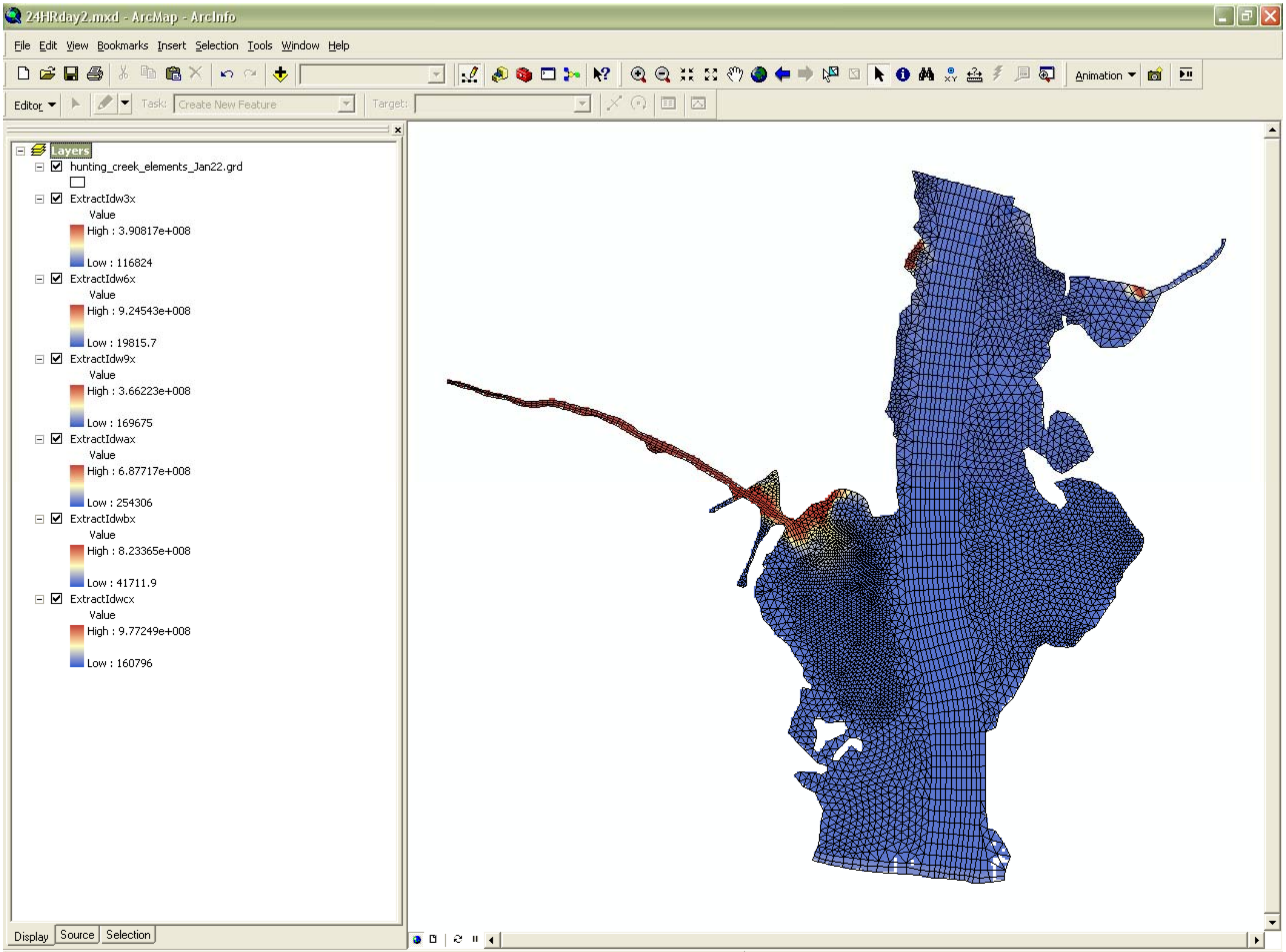
Fecal Coliform Calibration

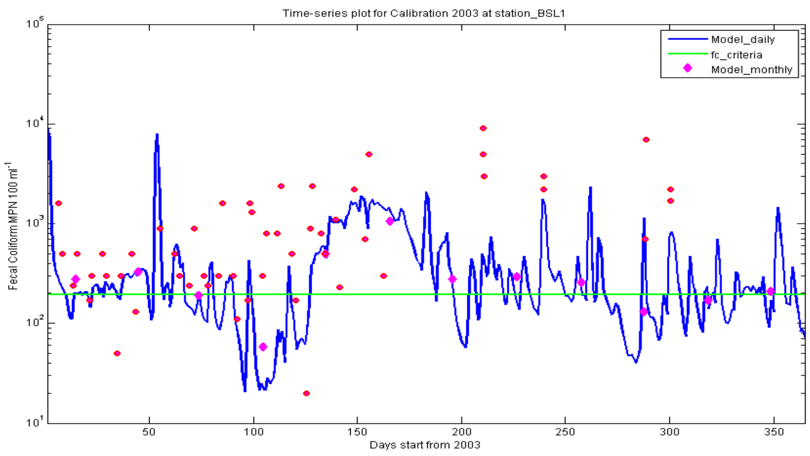
Monitoring stations

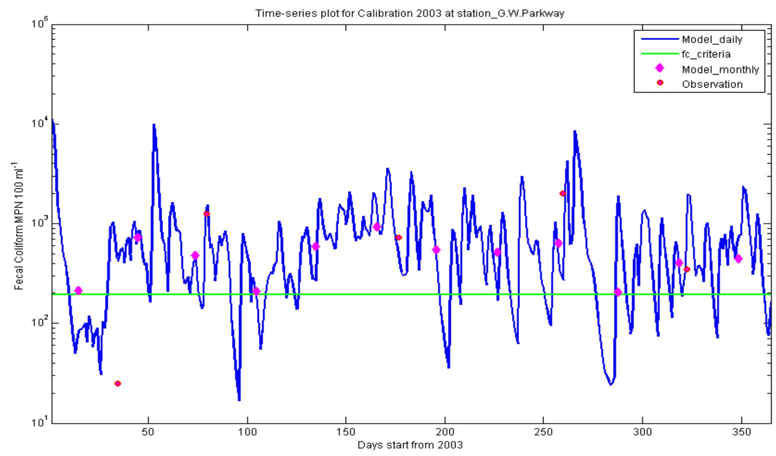
CSO stations

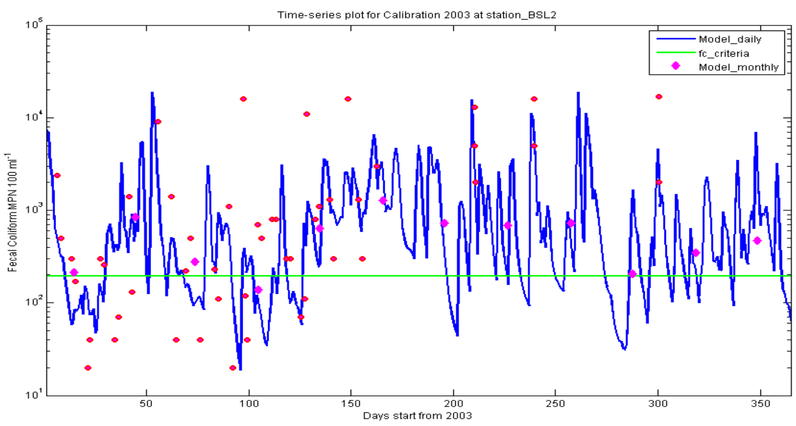
Point and non-point source entries for Hunting Creek and the Potomac River

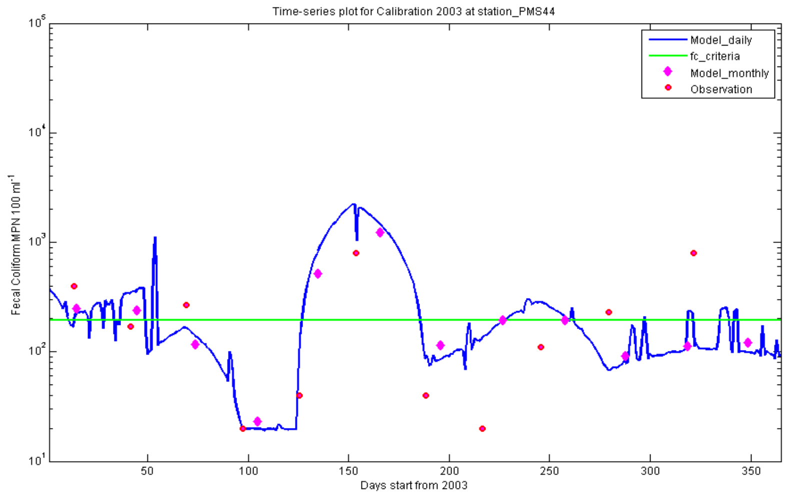
Example of Spatial Distribution of Fecal Coliform Concentration

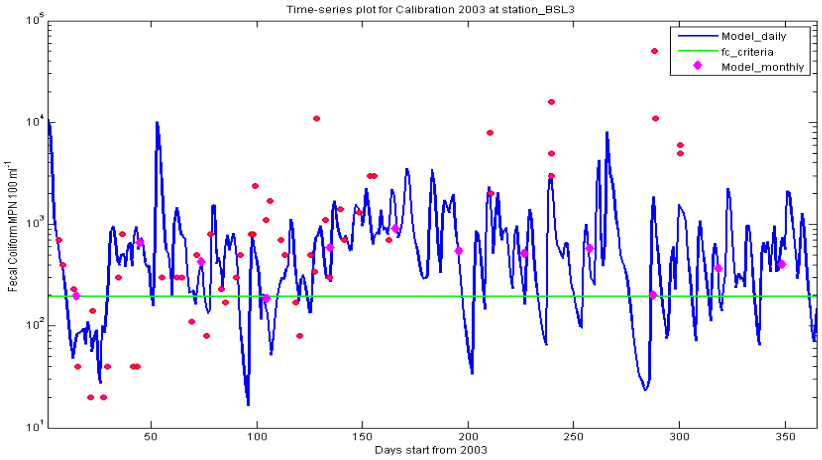



Time-series plot for Calibration 2003 at station_BSL1
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2003


Time-series plot for Calibration 2003 at station_G.W.Parkway
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2003

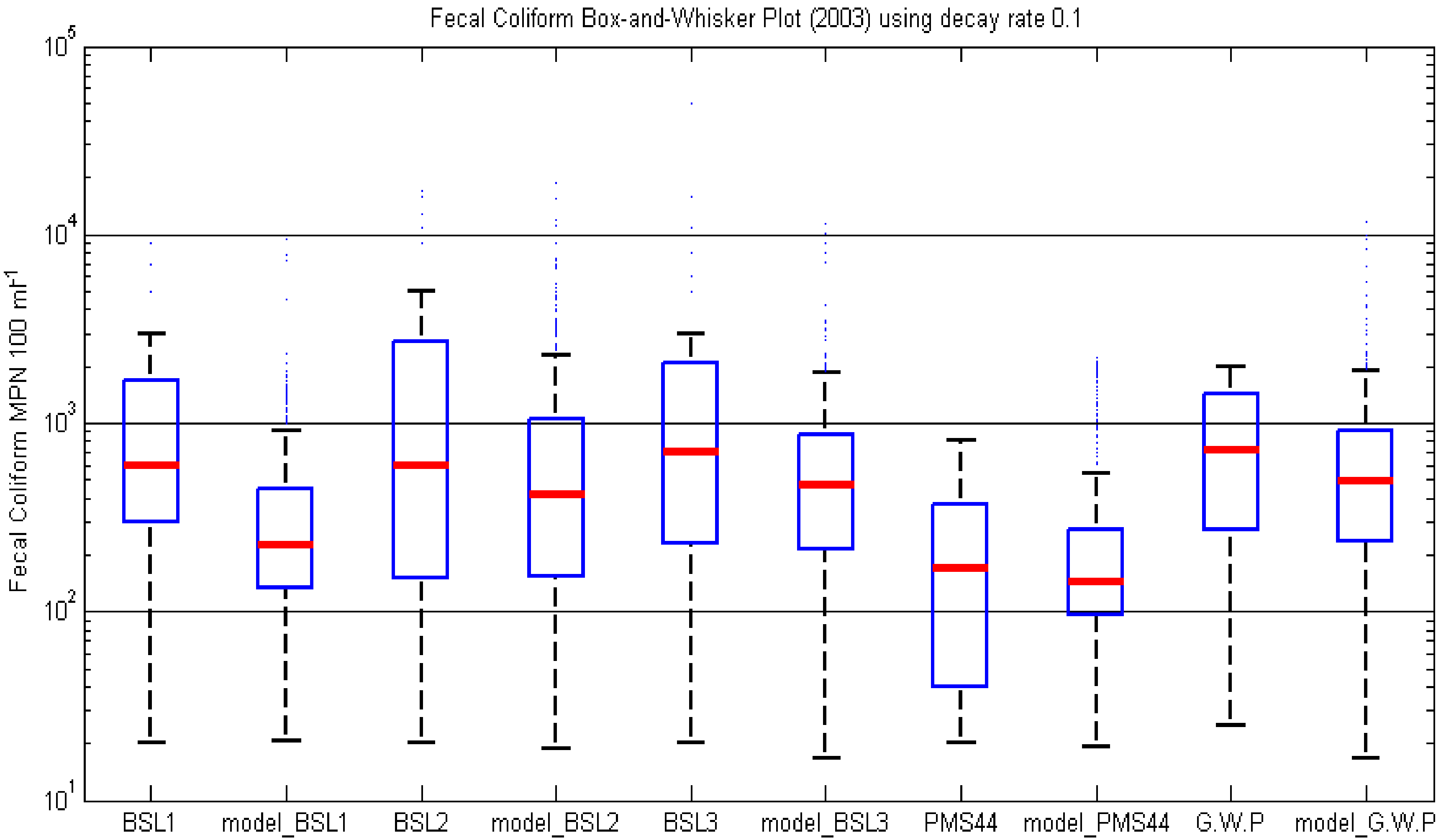

Time-series plot for Calibration 2003 at station_BSL2
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2003

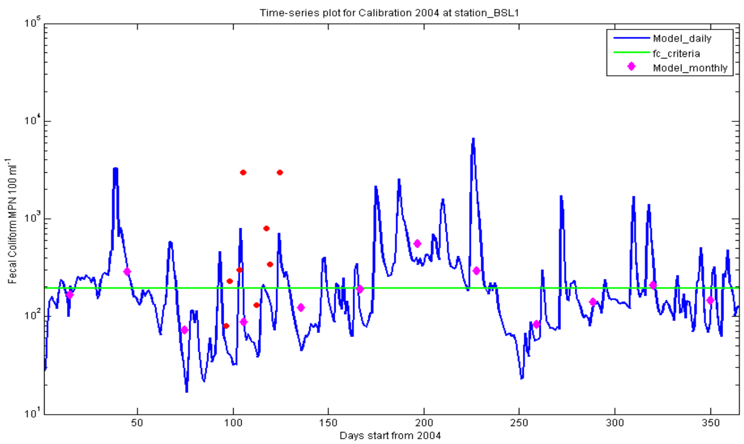

Time-series plot for Calibration 2003 at station_PMS44
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2003

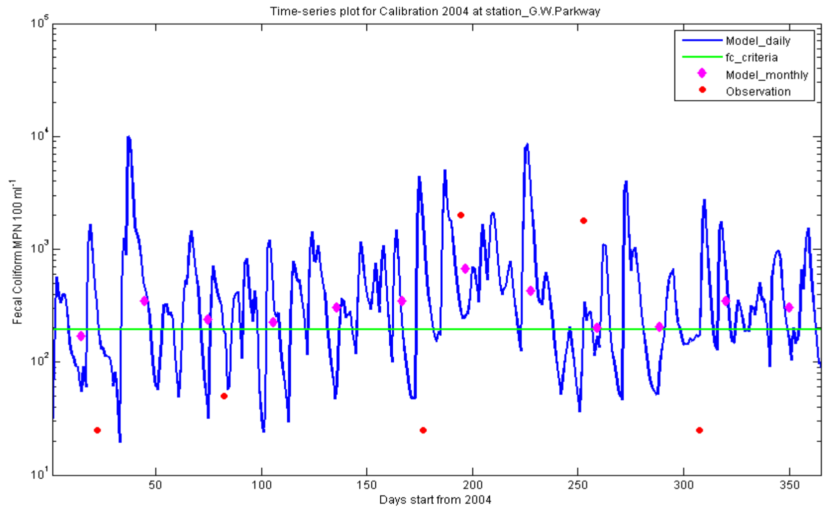

Time-series plot for Calibration 2003 at station_BSL3
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2003

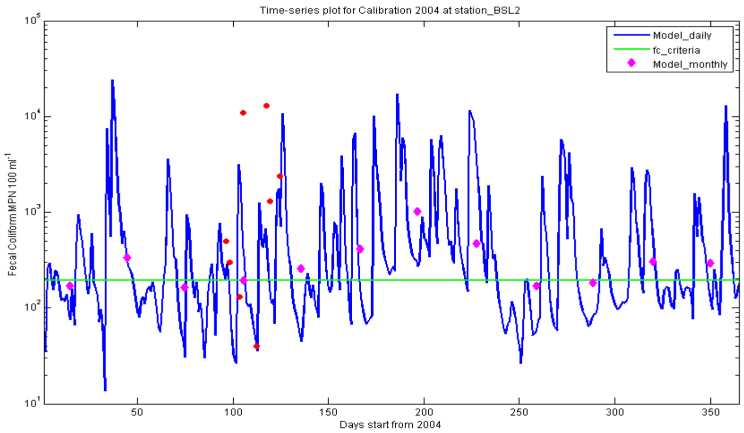
2003

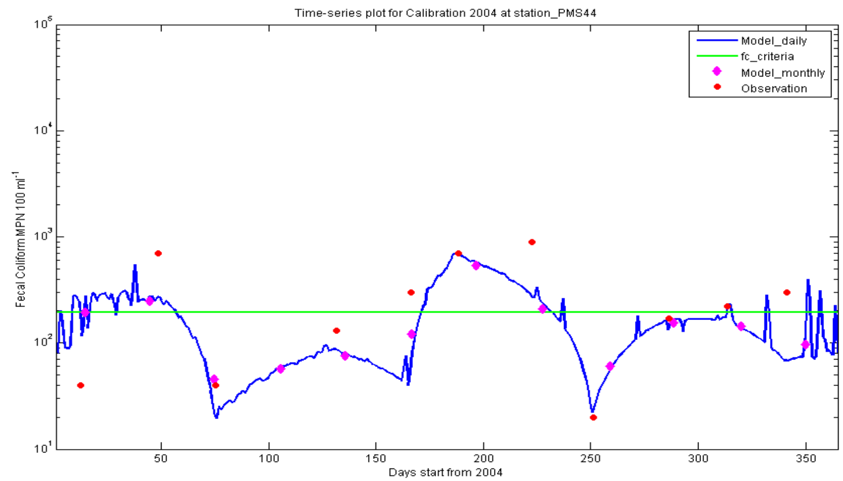
Fecal Coliform Calibration 2003

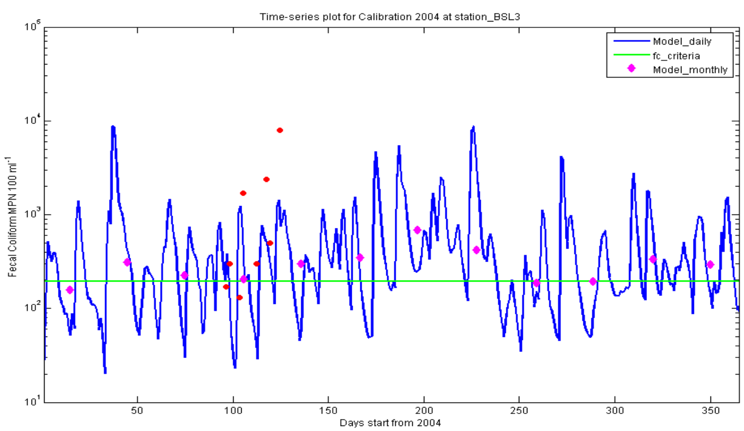



Time-series plot for Calibration 2004 at station_BSL1
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2004


Time-series plot for Calibration 2004 at station_G.W.Parkway
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2004

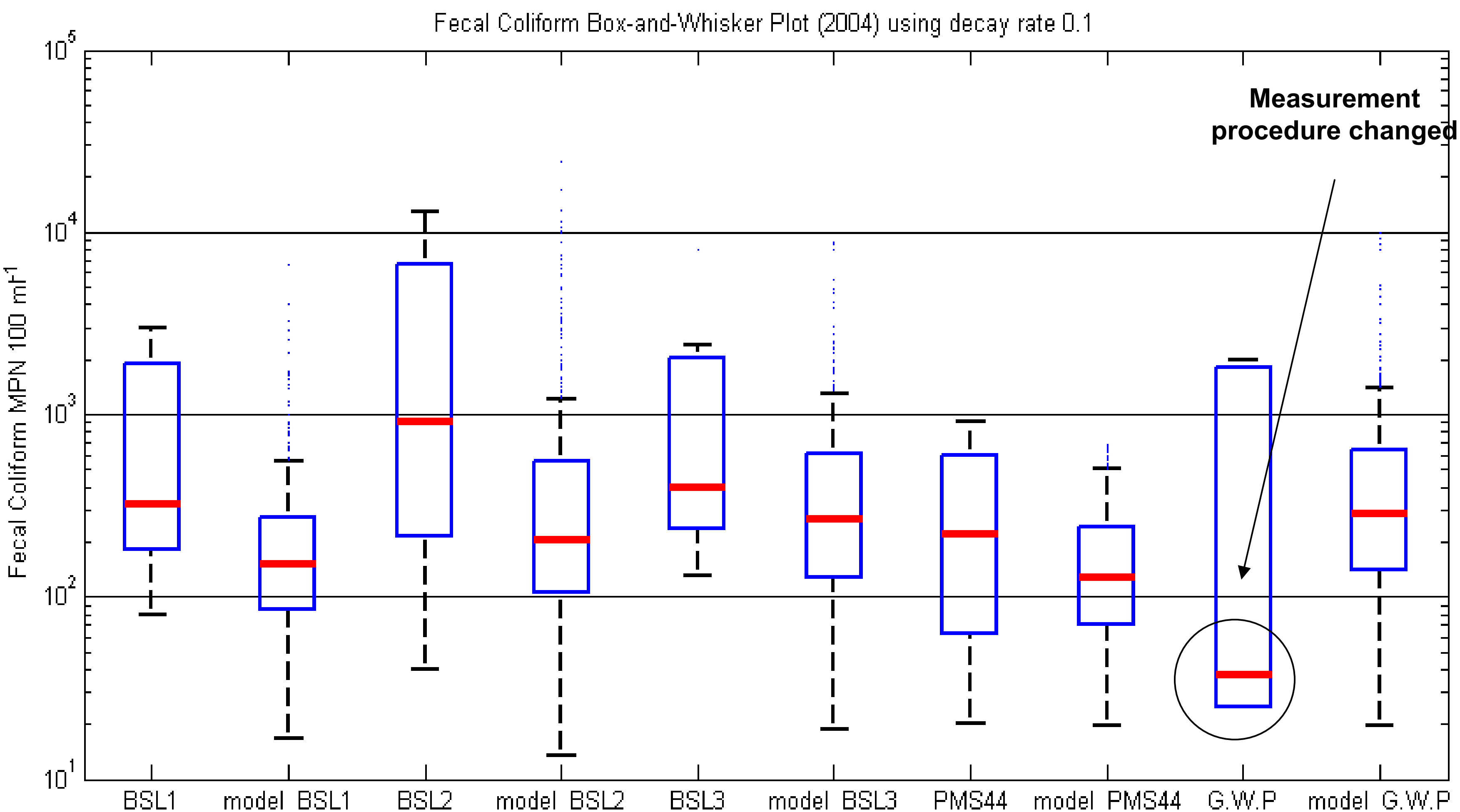

Time-series plot for Calibration 2004 at station_BSL2
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2004

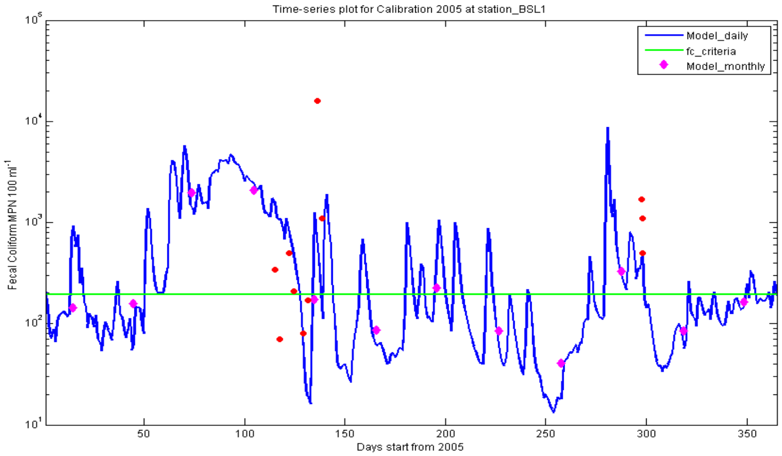

Time-series plot for Calibration 2004 at station_PMS44
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2004

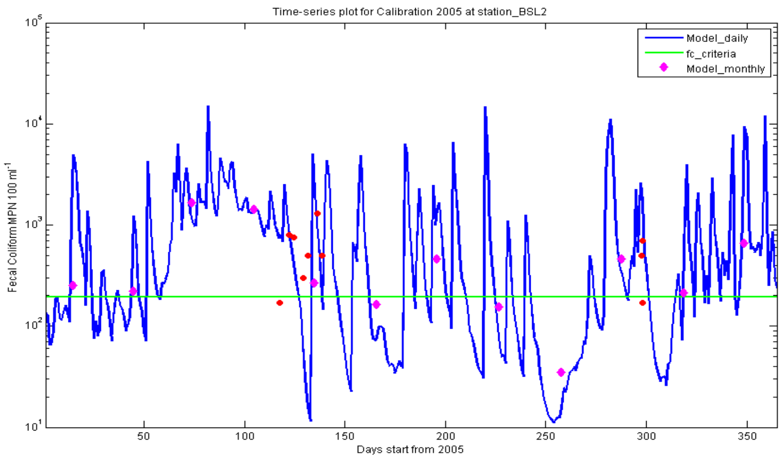

Time-series plot for Calibration 2004 at station_BSL3
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2004

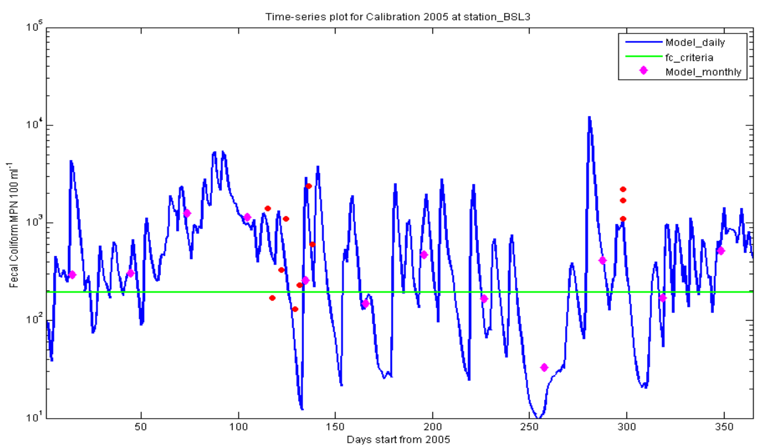
2004

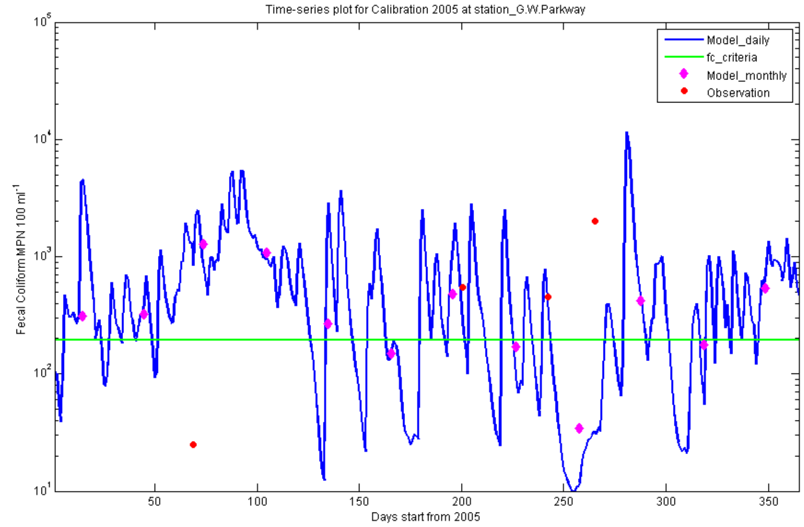
Fecal Coliform Calibration 2004

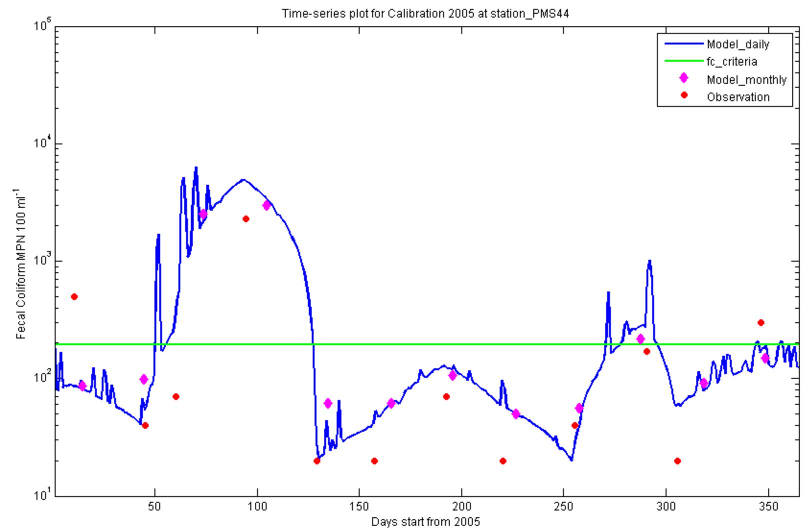



Time-series plot for Calibration 2005 at station_BSL1
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2005


Time-series plot for Calibration 2005 at station_BSL2
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2005

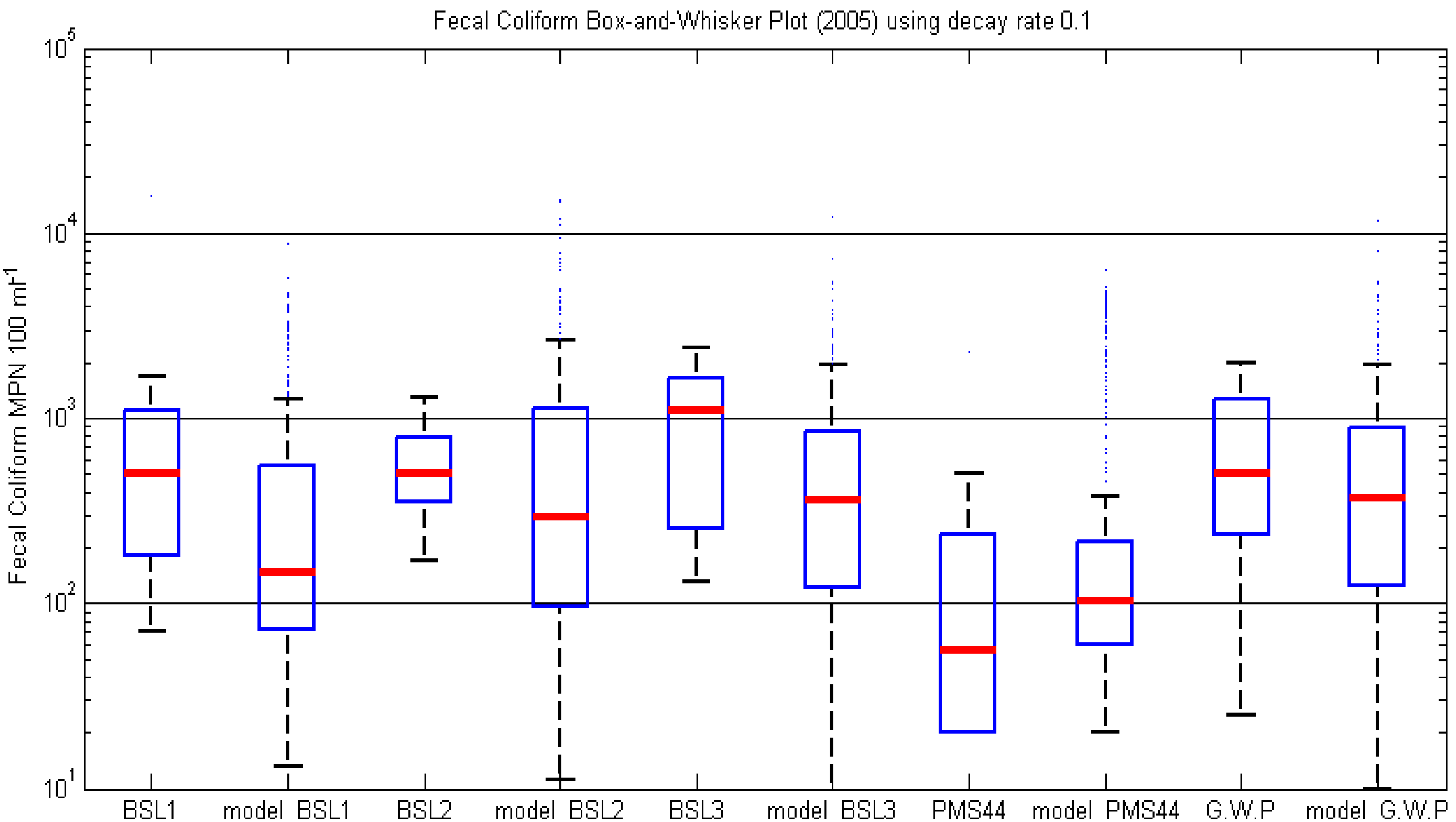

Time-series plot for Calibration 2005 at station_BSL3
Model_daily
fc_criteria
Model_monthly
Fecal Coliform MPN 100 ml^{-1}
Days start from 2005


Time-series plot for Calibration 2005 at station_G.W.Parkway
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2005


Time-series plot for Calibration 2005 at station_PMS44
Model_daily
fc_criteria
Model_monthly
Observation
Fecal Coliform MPN 100 ml^{-1}
Days start from 2005

2005

Fecal Coliform Calibration 2005



Model Sensitivity Analysis:

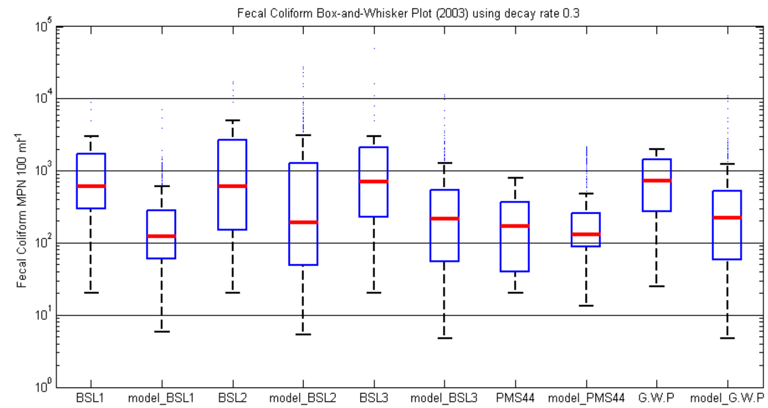
1. The bacteria decay rate (for example, 0.0/day, 0.2/day, 0.5/day and 1.0/day).

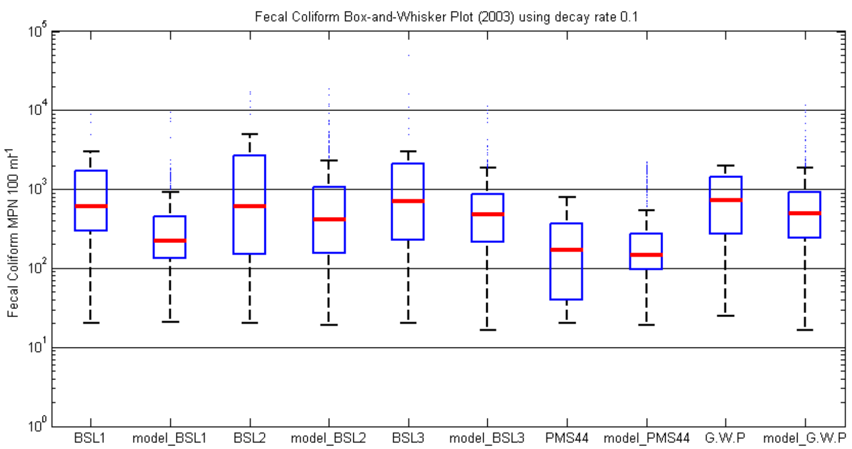
2. Sensitivity test example on decay rate specification in Potomac River

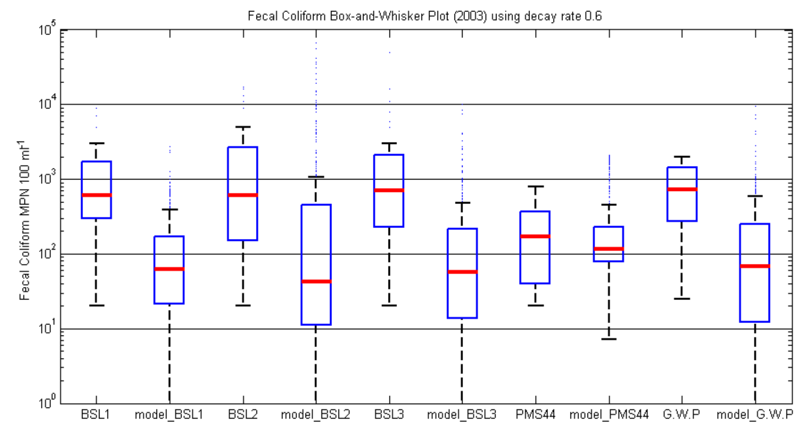
3. Individual loading sources reduction (for example,. 0%, 50%, 100%) for Scenario Runs

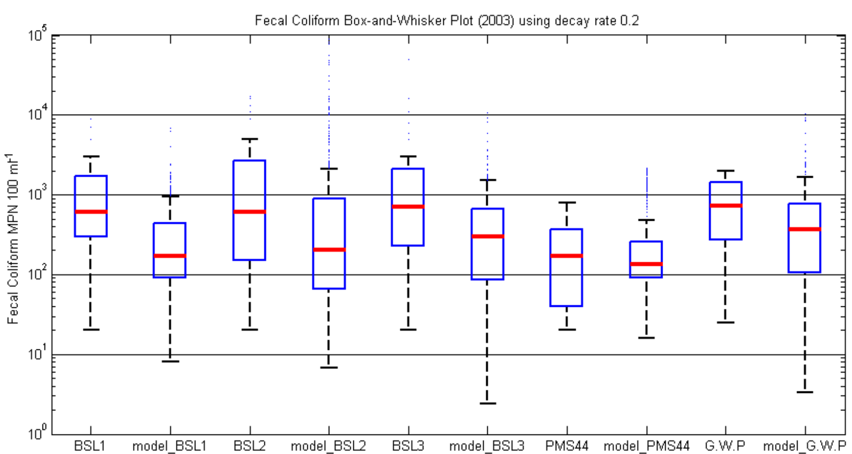
(1) Sensitivity test example on decay rate

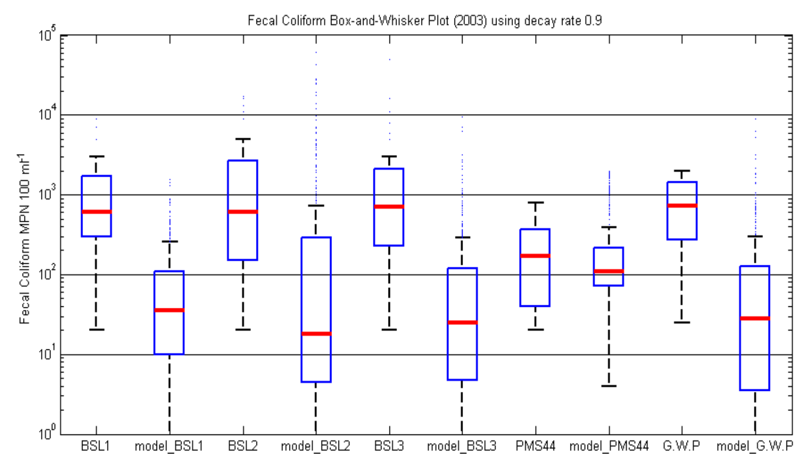
(0.1, 0.2, 0.3, 0.6, and 0.9 /day)



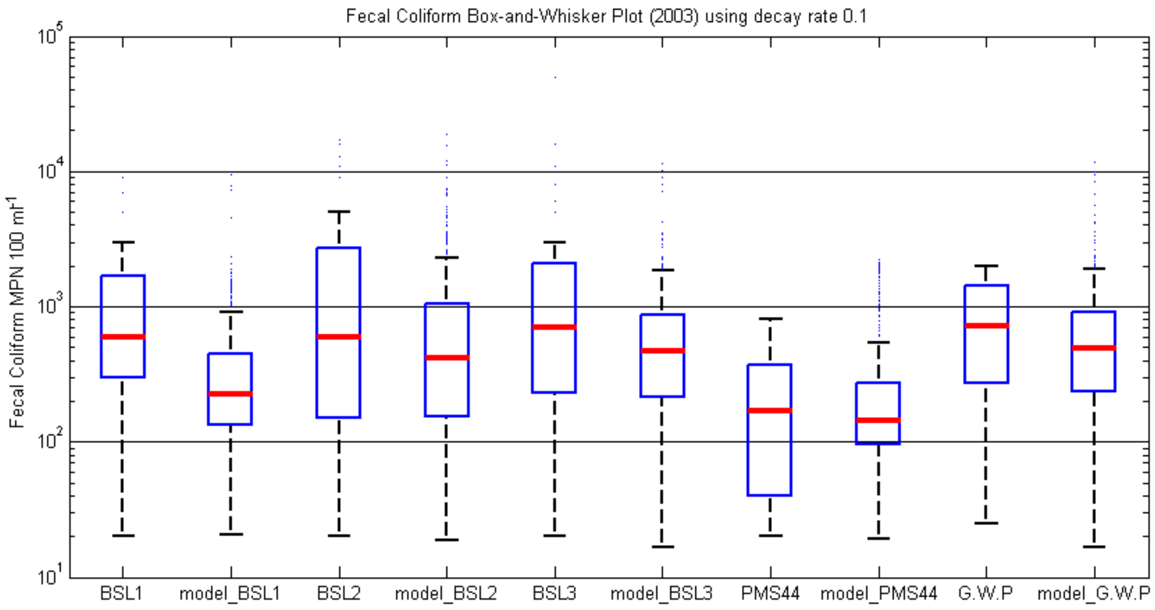






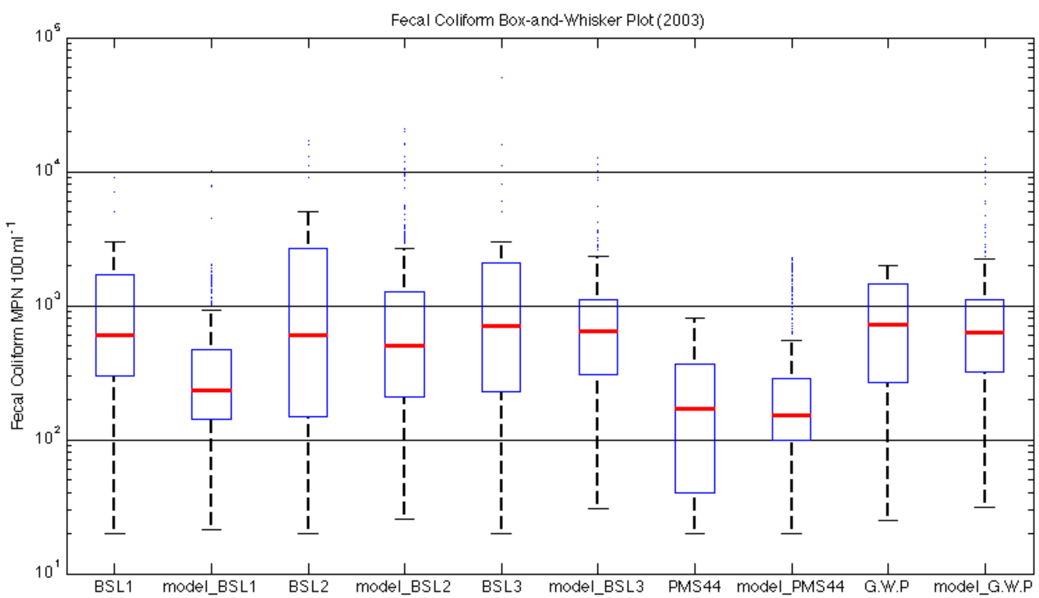


(2) Sensitivity Test example on die off rate specification in Potomac River



Decay rate = 0.1 /day at the Potomac River

Decay rate = 0 /day at the Potomac River



Issues Regarding Tidal TMDL for Hunting Creek

- Very complicated project
- Regulatory, policy, technical challenges
  - Requirements of statutory and regulatory provisions
  - Guidance and policy
  - Potomac boundary condition
  - How to assess against water quality standards (spatial aggregation of model cells)
- Reductions required from all sources.
- We are working with stakeholders to address challenges.
- Information is available on ftp site.

Schedule for Project Completion

- Final TAC Meeting – June 25, 2010
- Second Public Meeting – June 30, 2010
- Third Public Meeting – Mid July, 2010
- Draft Report Available for Public Comment – Mid July
- End of Public Comment Period – Mid-August
- Response to Comments, Revisions to Report – August and September 2010
- Final Report due to EPA: October 1, 2010

Note: Schedule beyond June 30th Public Meeting is subject to change.

Comment Period

Comment Period for Materials Presented at the TAC Meeting:

- June 25, 2010 to July 26, 2010
- Comments should be submitted in writing to:

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